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THE BRITISH VETERINARY JOURNAL

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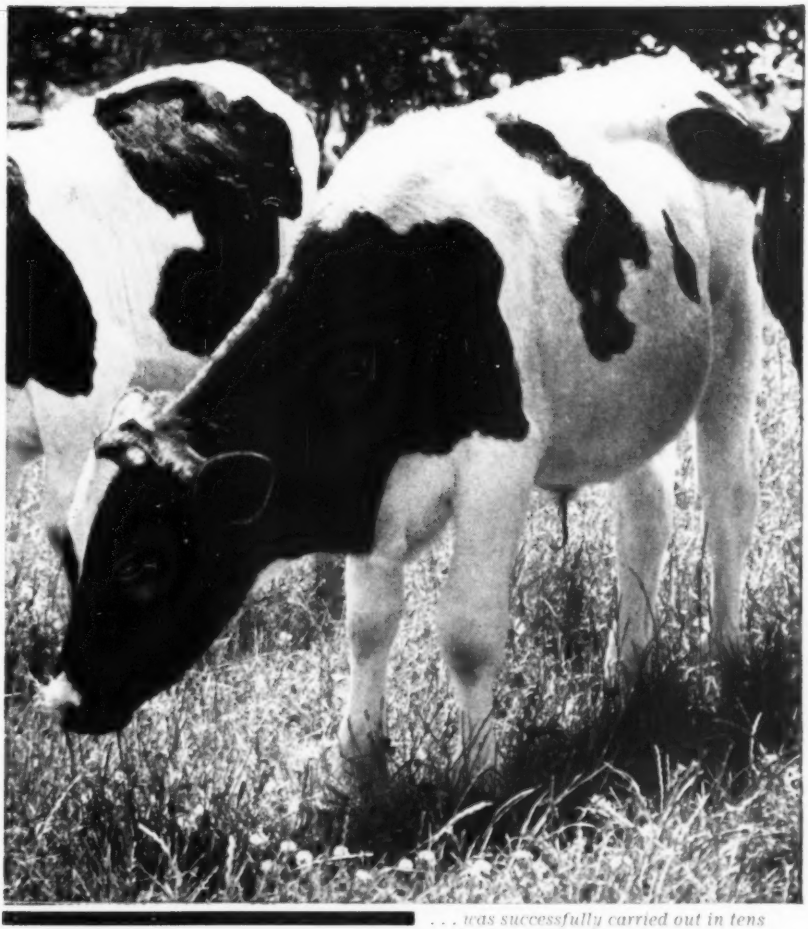

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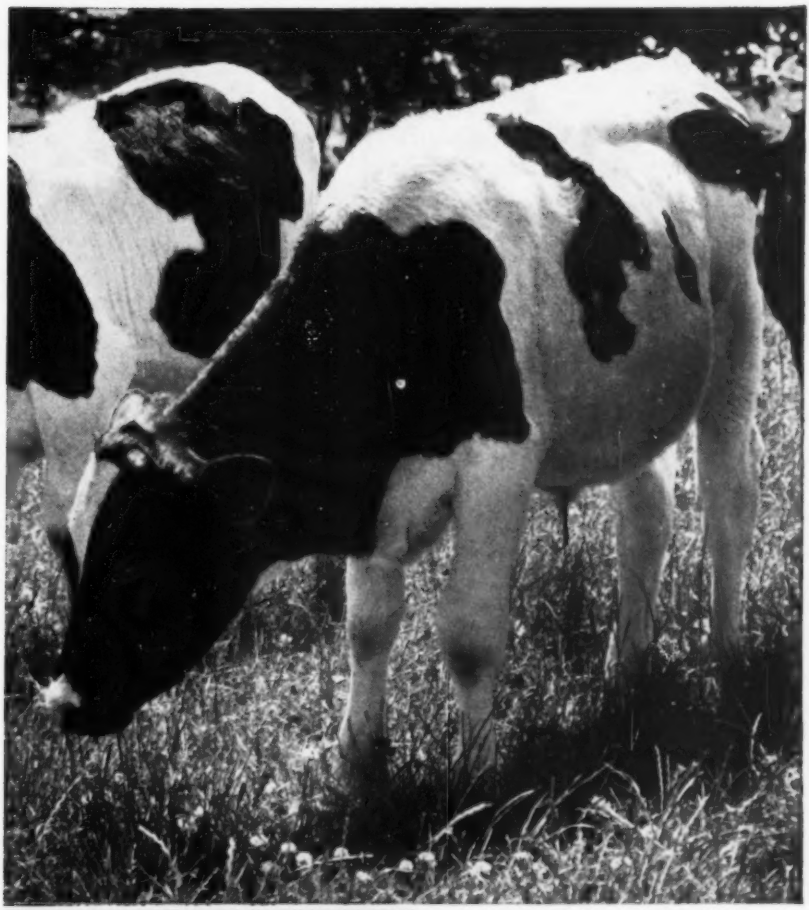

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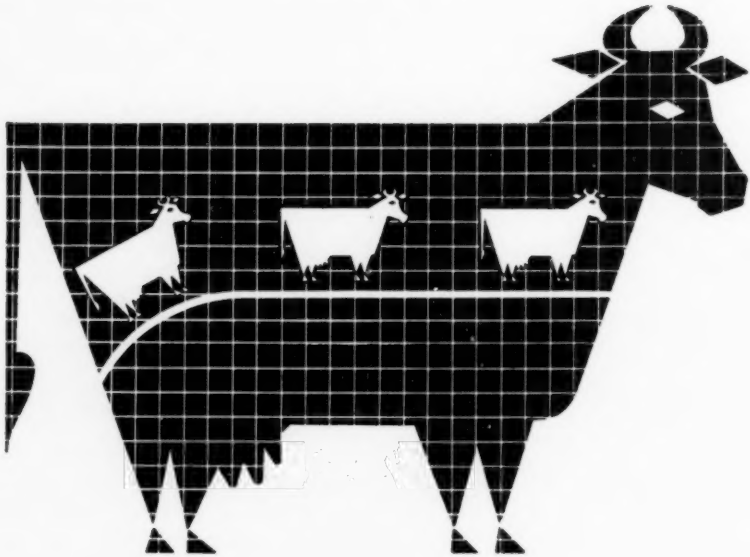

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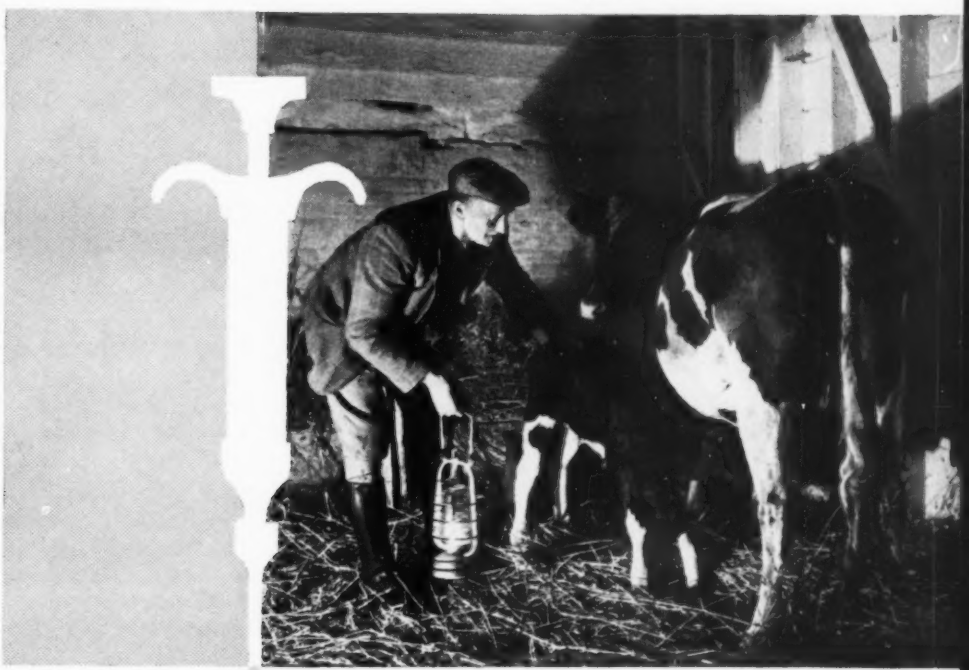

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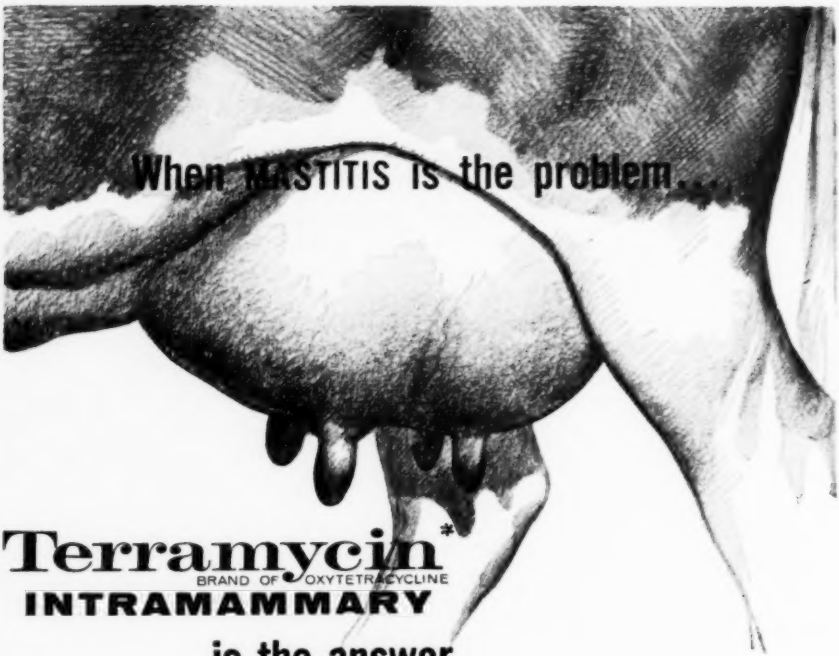

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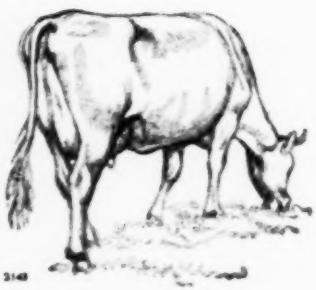

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TUBERCULOSIS

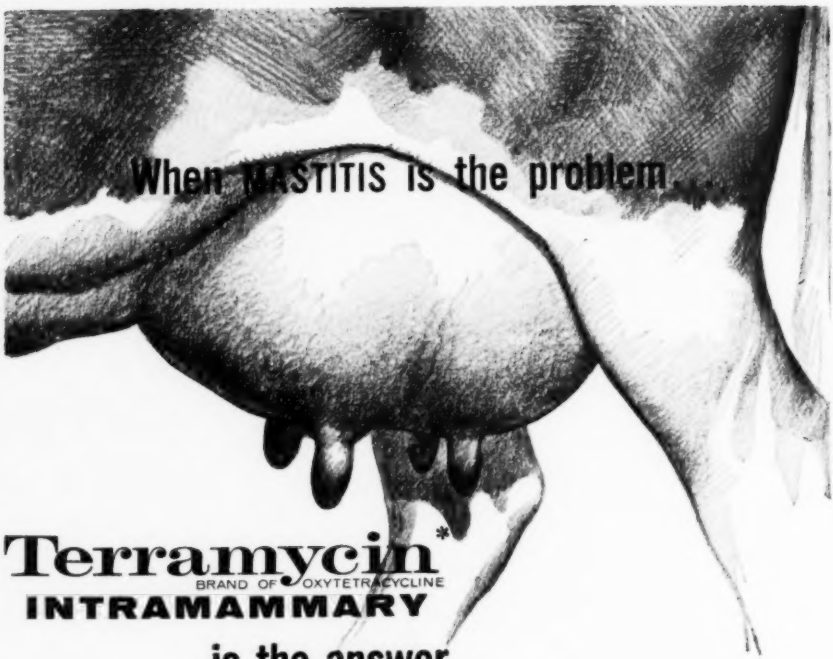
It has been announced that the whole of Great Britain is now an attested area. This means that tuberculosis has been brought to the point where its incidence is no longer a serious animal health problem. A few other countries have reached the same point but the problems involved in reaching this position are unlikely to have been greater than were those in Britain. Here the incidence of tuberculosis in attested herds is so low—0·15 per cent that the disease can be controlled with relative ease and eventually may even be completely eradicated.

The announcement is the culmination of a process which has been going on at least since the beginning of the century. It has depended, through official measures, the first in 1913, on the application of epidemiological principles to the control of a chronic infectious disease with long latent periods, in a highly susceptible population. The difficulties that this produced are not always appreciated now but many of the methods which were evolved only after overcoming puzzling and frustrating problems have become a part of the everyday life of many members of the veterinary profession in Britain. The scientific aspects of bovine tuberculosis have been well covered on many occasions and in numerous publications, but it is worthwhile at this stage to review the way which the eradication programme has gone, if only because other countries will follow when they reach a sufficient stage of development, and should know the problems and the way in which they have been solved here. It is however difficult to do justice to the immense amount of administrative work which has been involved, covering the inspection of farms, the issue of movement permits, the control both of partially attested and fully attested markets and such things as the evolution and operation of an adequate system of identification of cattle and tracing of reactors.

The whole of the veterinary profession have taken part in the eradication programme in one way or another and especially those in private practice in rural areas. At the same time a unified animal health service has been evolved and the investigation and control of other diseases has been expanded and stimulated.

With the reduction of infection in cattle the incidence of bovine tuberculosis in other animals is tending to decrease. Avian tuberculosis is also becoming less frequent. The disease should never again pose the same sort of problems as it did in the past.

Although the control of tuberculosis of cattle began as a public health measure, principally because of the dangers from infected milk, in its latter stages it has become much more a means of improving animal health and productivity. While the disease in man and in cattle has the same fundamental epidemiological features, the systems of control and eradication have depended on different techniques. These have in man, together with new methods of treatment and the changing social background, produced a spectacular decline in the incidence of the disease and there is no doubt that tuberculosis will soon become a very rare disease in this country both in man and cattle.



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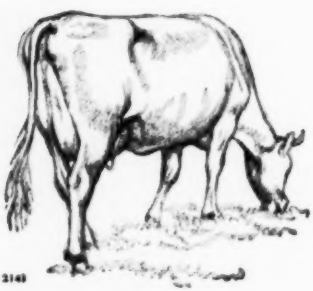

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THE EARLY CONTROL OF BOVINE TUBERCULOSIS*

The approximate time of introduction of bovine tuberculosis into this country can only be a matter of conjecture. It is known, however, that it was prevalent amongst cows in Northern Italy at the beginning of the Christian era and that the Romans brought cattle to Britain to cross with the indigenous breeds. During the thirteenth century Lombardy cattle were imported into Holland, and in all probability took disease with them. By the seventeenth century, Dutch cattle were being imported into this country in considerable numbers, a movement which appeared to correspond with the advent of primitive dairying.

It was not until the end of last century, however that the incidence of bovine tuberculosis reached such proportions in this country as to attract attention. This increased incidence was no doubt due to changes brought about by the industrial revolution, and was attributable to the same factors as those responsible for the increase in tuberculosis amongst humans. The human population tended to congregate in the industrial areas and thus created an ever-increasing local demand for dairy products, first as cheese, butter, and butter-milk, and later, as facilities improved, in the form of fresh milk. As a result the pattern of farming in the surrounding districts gradually changed to meet the changing need. An increasing number of farmers switched to dairying and this in turn demanded a change in farming practice in order to produce the necessary amount of winter feeding, a change which was probably the forerunner of intensive dairy farming as it is known today. Even before this period many town dairies had been established. The cows were housed continuously and their food supply was grown in the outskirts of the townships.

As with the human population these changes led to bad housing conditions. Byres were often hastily-improvised structures and most were dark, poorly ventilated hovels. In fact ventilation was often purposely reduced to a minimum on the theory that a warm atmosphere increased milk yield, a theory which was slow to die in later years. These defects were further aggravated by the tendency to over-stock with a view to producing as much milk as possible.

As a result of the new opportunity many farmers ceased to rear young stock. They preferred to keep more cows on the food and labour which would normally have been expended in rearing replacement cattle. At first replacements would no doubt be purchased privately from the more remote farms, but as this trade increased, and with the advent of more markets and better travel facilities, the stage was set for the dealer and for the interchange of dairy cows on an unprecedented scale.

* Compiled by the staff of the Animal Health Division of the Ministry of Agriculture, Fisheries and Food.

THE INCIDENCE OF THE DISEASE AND THE LOSSES CAUSED

All these circumstances and many others provided a fertile field for the spread of disease in general and of tuberculosis in particular. In fact it is true to say that the incidence of tuberculosis was often in direct proportion to the distance of the cow-shed from the industrial area. It was not until the first decade of the present century that farming and public opinion awakened to the repercussions of this trend of affairs.

The Economic Advisory Council's Committee on Diseases of Cattle under the Chairmanship of Sir Fredrick Gowland Hopkins (1934) accepted that 40 per cent of dairy cows in Great Britain were affected with tuberculosis. Experience in the field indicated that the average incidence was at least no less than this figure and it must be remembered that in some of the more intensive dairying districts it was nearer 100 per cent. Wastage due to clinical and sub-clinical disease in these areas was heavy, and in times of economic depression tuberculosis alone brought many farmers to the brink of financial disaster. Apart from the economic loss caused by the death or the early culling of cattle suffering from advanced tuberculosis, sub-clinical disease also took its toll. Infected herds were, of course, subject to other diseases associated with intensive dairying and there is no doubt that when these were superimposed on animals already affected with tuberculosis, losses were comparatively much greater. It was quite a common experience to find stock-owners who, having reared their entire calf crop, had no surplus stock to sell, the young stock being required to replace wastage in the dairy herd. Ample proof of the basic cause of this state of affairs was produced when these same owners in later years changed over to tubercle free cattle.

Apart from direct losses on the farm due to tuberculosis, a further loss was sustained at the slaughterhouse. In Edinburgh it was estimated that in 1931 from 31,567 cattle killed, 100 tons of tuberculous meat were condemned. This figure cannot be taken as an average for the country as a whole since the proportion of cast dairy cows killed in any particular slaughterhouse would have a direct bearing on the number of condemnations. Nevertheless it can be taken for granted that the figures are fairly representative of the position in city slaughterhouses and give some idea of the total loss involved. It does not, however, take into account condemnations amongst pigs due to infection with the bovine type of organism.

THE EARLY PUBLIC HEALTH MEASURES AND THEIR EFFECT

No official effort was made to control bovine tuberculosis until 1913 when the Tuberculosis Order was introduced. Suspended during the 1914–18 war it was re-introduced in 1925. This Order made certain manifestations of tuberculosis notifiable. It was basically a public health measure and not an attempt at eradication. All it could hope to achieve was the elimination of the more advanced cases of pulmonary tuberculosis and a reduction in the infection of milk with tubercle bacilli. By the time an animal had developed detectable clinical symptoms it had already done a considerable amount of damage to

the herd. In addition there were many cows which were obviously affected with disease but were covered by the terms of the Order and consequently could not be slaughtered. Although the Order served a useful purpose in the field of public health, no significant reduction in the number of reported cases of tuberculous milk was achieved until the policy of eradication was adopted (Fig. 1).

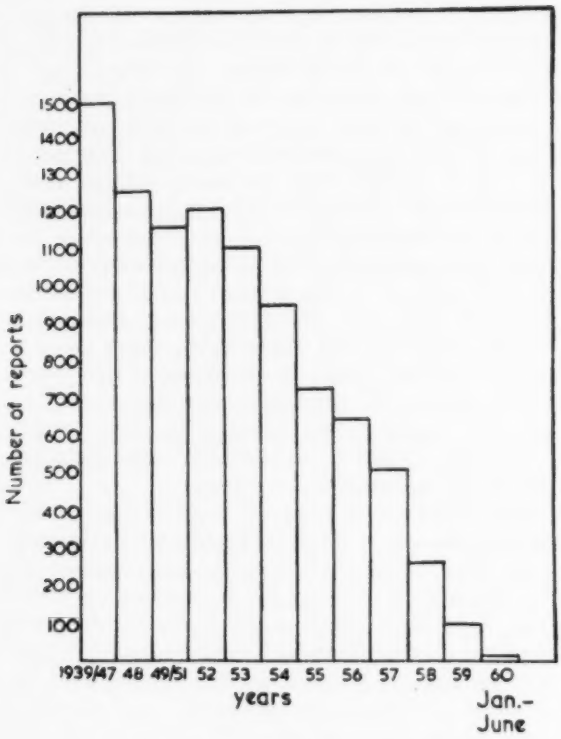

FIG. 1
Reported cases of Bovine Tuberculosis, 1939-1960

The total number of cases dealt with under the Tuberculosis Order varied from year to year but the numbers tended to increase with the more effective administration of the Milk and Dairies Acts, and it was not until the Attested Herds Scheme was really under way that there was any appreciable and permanent reduction. In 1926, the first complete year after the introduction of the Order, 17,348 cattle were slaughtered, and this figure rose steadily until the peak year in 1936 when 23,716 were dealt with. The various headings under which these were slaughtered were as follows:

(*a*) Giving tuberculous milk	602
(*b*) Tuberculosis of the udder	5,255
(*c*) Tuberculous emaciation	5,162
(*d*) Chronic cough and showing other clinical symptoms of tuberculosis	12,783

At *post-mortem* examination 0·3 per cent were found not to be affected with tuberculosis, 37·7 per cent were not in an advanced state of disease, and 62 per cent were advanced in terms of the Order. The number found affected on *post-mortem* examination during 1936 represented 2·5 per cent of the total number of cattle on the farms where disease within the scope of the Order was found to exist. As far as distribution was concerned the largest proportion of cases were found in the intensive dairying and industrial areas such as Chester, Lancaster, Stafford, and the West Riding of Yorkshire.

Parallel to the introduction of the Tuberculosis Order the Milk and Dairies Acts were introduced. These gave Local Authorities power to inspect dairy herds, and, in conjunction with the powers of slaughter under the Tuberculosis Order, were at least a step in the right direction as far as public health was concerned. They also gave powers to make byelaws for regulating the structure, lighting, ventilation, etc., of dairy premises. While these measures were primarily in the interests of public health they had a profound effect on the health of the dairy cow where they were applied. This was particularly true in the case of ventilation.

In 1923 the first Milk (Special Designation) Orders came into force. These again were public health measures aimed at producing milk of a specified bacterial standard under good sanitary conditions and from cows which had passed a tuberculin test. While prior to 1923 a few owners had maintained a tuberculin tested herd in their own interests, and without any financial incentive, there is no doubt that the introduction of "Tuberculin Tested" milk had the side effect of awakening the more enlightened owners to the possibility of freeing their herds of tuberculosis as an animal health measure.

As a result of the foregoing legislation it became necessary for local authorities to appoint veterinary surgeons, either in a whole-time or part-time capacity. For those appointed in the early days the task was not easy. There had been no previous form of control, and while some dairy farmers welcomed the new state of affairs, others resented it. A great deal of diplomacy and persuasion had to be exercised in order that the farmer might come to appreciate his responsibility to the community. That apart, however, those veterinary surgeons engaged in this early work soon found there was still much to learn about tuberculosis, and what is common knowledge today had to be discovered the hard way in the course of the daily round.

Broadly speaking it can be said that as far as tuberculosis was concerned herds fell into three main categories, the upland herd which was either free or comparatively free of disease, the herd close to an industrial area and in which the incidence of disease was often 100 per cent, and the herd which lay geographically between and where the incidence varied, depending on the husbandry. There were many reasons for this position but there is no doubt that

the aged infected cow was the most important factor in spreading disease. Experience showed that on the upland farm where stock was home bred and the cows were sold as they reached their second or third calf, there was a minimum incidence of tuberculosis. In many cases the weight of infection in heavily infected herds was considerably reduced solely by methodically reducing the average age of the herd and rearing replacement stock. In the flying herd on the other hand there was usually a predominance of aged animals with a corresponding increase in the incidence of disease.

Bad housing conditions also played their part in disseminating disease and in this connection the requirements of the Milk and Dairies Orders had often an unfortunate repercussion. The legislation only applied to lactating cows but many farmers kept more adult stock than their registered cow-shed could accommodate. The result was that dry cows were housed elsewhere, often in the worst possible conditions, and frequently amongst the young stock. Consequently the followers became infected at an early age and in many the disease had reached an advanced stage before they entered the dairy cow-shed as calving heifers. Such animals often fell by the wayside at an early date. When young stock were kept apart from the dairy cows and were not fed on raw milk they were usually free from tuberculosis when they joined the milking herd. This was a common experience even in herds where the cows were heavily infected and where no particular effort to prevent indirect spread of infection had been taken.

Another factor which had a considerable influence on the disease position was the advent of contracts to produce a stipulated gallonage of milk throughout the year. The practice encouraged owners to adopt the flying herd system and it is very doubtful if the extra income covered the resultant loss from disease.

As a result of the various legislative measures governing milk production many owners became conscious of their responsibility to the consumer, so much so that as far as tuberculosis of the udder was concerned they were often inclined to act on their own initiative rather than report the condition to the proper quarters. Rather than include any suspicious milk in the bulk supply they preferred to feed it to calves or pigs. As a result batches of calves became infected at a very early age, and in many cases, even if they survived to reach their first lactation they were undersized and unthrifty. It is of note that *post-mortem* examination of infected month-old calves occasionally revealed calcified lesions in the mensenteric glands, an experience which made one guarded in attempting to age tuberculous lesions.

Cases of congenital tuberculosis were not uncommon but it is doubtful if they were a significant factor in the spread of disease compared to those already mentioned. Such calves often died before reaching maturity. Those which lived probably added little to the weight of infection in what was already a badly infected herd. Heredity, however, has been said to play an important part. This is difficult to substantiate but it may be that certain lines of cows were particularly susceptible to tuberculosis. Be that as it may, it was quite a common occurrence when dealing with a case under the Tuberculosis Order

to be told by intelligent and observant owners that it was the last of a family all of which had been dealt with similarly.

Apart from its effect on livestock economy bovine tuberculosis was of marked public health significance. According to the annual report of the Department of Health for Scotland (1933) 10 per cent of raw churn milk supplied to the four principal cities was infected with *Mycobacterium tuberculosis*. In Glasgow the percentage reached 13·4 per cent. When transported in tanks the percentage rose to the alarming figure of 37·5 per cent. During the years 1928–1937, 8·2 per cent of samples reaching seven cities in England were found to contain virulent tubercle bacilli. In Manchester the figure was 13·2 per cent. As far as the individual cow was concerned it was found that 1·4 per cent of individual samples from cows which had reacted to the tuberculin test were positive (Jordan 1933).

These figures were sufficient to indicate the unsatisfactory state of affairs obtaining at that time. Reports regarding tuberculous milk were received continuously from one source or another whereas today this is a rare occurrence. The resulting clinical examination to detect the offending cow was not a simple diagnostic procedure. Manual examination of the udder had its limitations and was often complicated by the presence of a chronic mastitis due to other pathogens. That apart, however, there was often a sense of futility in one's endeavours, and even if there was the satisfaction of having detected a case of tuberculosis of the udder, the best that could be hoped for was to reduce gross infection in the milk.

THE SPECIAL DESIGNATION OF MILK & THE DEVELOPMENTS WHICH FOLLOWED

The first real effort to provide the public with a reasonably safe milk supply was the introduction of the Milk (Special Designation) Orders in 1923. Progress at first was slow, mainly due to the standard required for the cow-sheds and dairies. By 1925 there were only 36 "Certified" and "Tuberculin Tested" herds in Scotland, 144 in 1930, and 212 in 1935. During this period there were few facilities for the purchase of tuberculin tested cows and consequently the farmer had no option but to maintain a closed herd. In a few counties local arrangements were made with auctioneers for any cattle from "Certified" or "Tuberculin Tested" herds to be sold first. Otherwise there were no facilities for segregation such as pertained later under the Attested Herds Scheme. A few owners did purchase cows in the ordinary market and subjected them to the tuberculin test before adding them to the herd. This, of course, led to difficulties and often disastrous results since such animals frequently passed the first test but failed at a later one after being admitted to the herd.

In spite of many difficulties however, many of the more enlightened dairymen, and particularly owners of pedigree herds, became licensed under the Orders. Some were stimulated by the discovery of tuberculosis of bovine origin in some member of their own family. At first the prescribed tuberculin test was the subcutaneous coupled with the ophthalmic. This was a time consuming business and would, of course, be quite impracticable under present

day conditions. The test was usually commenced about nine o'clock in the evening and readings taken from six o'clock the following morning onwards.

In December 1925, authority was given to use the double intradermal test combined with the ophthalmic as an alternative. This was immediately adopted not only because it was less tedious, but primarily because it was a more accurate test. It was quite a common experience at the change over to find odd reactors in herds which had regularly been tested till clear by the older methods, and in those few cases where a *post-mortem* examination was possible the lesions appeared to be old-standing.

In 1934 the use of Cambridge synthetic medium tuberculin was authorised. This provided a distinct improvement, for while it did not appear to detect any more reactors, the test was much easier to read.

As already indicated, progress under the Milk (Special Designation) Orders was slow. Gradually, however, as a result of propaganda the farmers began to realise the benefits of having a tubercle free herd and the public to demand a clean, disease free product. Up until 1935 these developments were purely in the interests of public health but the herds licensed under these Orders formed the corner stone as it were of the Attested Herds Scheme and the experience gained in the process made its contribution to the terms of the Scheme. The early use of the tuberculin test in establishing many tubercle free herds did much to impress the farming community with the reliability of this method of diagnosis.

References

Department of Health for Scotland. *Tuberculous Infection in Milk.* Annual Report (1933).
Economic Advisory Council. *Committee on Cattle Diseases Report* (1934).
Francis, J. (1947) *Bovine Tuberculosis.* London: Staples Press.
Jordan, L. (1933) *Eradication of Bovine Tuberculosis,* Medical Research Council. Special Report Series No. **184.** London: His Majesty's Stationery Office.

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THE PROGRAMME FOR THE ERADICATION OF BOVINE TUBERCULOSIS*

Although the tuberculin test had been used to diagnose tuberculosis in dairy cattle in Great Britain since the early part of the century no rational attempt was made to stimulate the eradication of the disease until 1935 when the first Attested Herds Scheme was introduced. Prior to that date the orientation had been towards the production of tubercle-free milk, and although the milking cows in the officially recognised tuberculin tested herds were submitted to periodic tests there was no obligation to test the young stock. The frequency and extent of testing and the regulations applied to "Tuberculin Tested" herds were sufficient to give a good measure of protection to the milk supply but were not necessarily capable of producing or maintaining a tubercle-free herd.

ERADICATION FROM THE HERD

The incidence and distribution of reactors is a guide to the procedure to be followed in eradicating tuberculosis from the herd.

Where few reactors are disclosed they should be removed and testing continued at intervals of two to three months until the disease has been eliminated.

Should a high incidence of reactors prevent their immediate disposal an attempt may be made to segregate the reactors after removing any animals showing clinical signs of the disease. Calves born to reacting cows must be removed at birth to the tuberculin negative group. Periodic testing of the non-reacting cattle should be continued until such time as all reactors have been removed and a single clean herd test has been obtained. The more complete the isolation the greater will be the degree of success.

Regard should be paid to group incidence within the herd and if a high proportion of reactors is disclosed the entire group should be removed. It was commonly found in dairy herds that although the adult cattle were largely infected, the young stock had a low reactor incidence. In this event successful eradication normally followed the removal of the adult cattle and any reacting young stock. The premises were disinfected and the cow-shed subsequently restocked by the purchase of young attested cattle and short interval tests were continued until the herd was proved to be clear of any residual infection.

The Attested Herds Scheme was designed to eradicate bovine tuberculosis from individual herds of cattle and to protect them from reinfection. The procedures outlined above were used by stock owners during private testing

* Compiled by the staff of the Animal Health Division of the Ministry of Agriculture, Fisheries and Food.

prior to the herd being accepted into the attested scheme. Under the scheme introduced in 1935 a bonus on milk sales of one penny per gallon was paid to owners of attested herds and, in the initial stages, owners of herds which had been licenced under the "Tuberculin Tested" milk legislation were mainly attracted by the scheme. Progress was slow. Few attested cattle were available for the formation of new herds which might qualify for direct entry into the scheme, and progressive farmers were obliged to gain attested status for their cattle by the process of repeated herd testing until such time as two consecutive clear tests had been obtained. Subsequently an official test of the herd was carried out after a lapse of 60 days from the last previous test and, if no reactors were revealed, the herd was registered as being of attested status. A minimum interval of 60 days between herd tests has been a routine practice in the eradication programme. Attested cattle were protected from reinfection by arranging a physical break between the herd and neighbouring non-attested stock, by insisting on separate transport and isolation in markets, and by prohibiting the direct movement of all but attested cattle into the herd. In 1938 with a view to attracting stock owners who were not milk producers an alternative bonus on a *per capitem* basis was offered. Parallel to the widening of the financial attraction a scheme of monetary aid towards private testing was introduced and it is of interest that the total number of attested herds having moved from 414 in 1936 to 4,644 in 1938 had jumped to 16,300 two years later. During the war the scheme was for a time closed to all except licenced "Tuberculin Tested" herds. But in 1943 the introduction of an increased premium of four pence per gallon on "Tuberculin Tested" milk resulted in marked progress in dairying districts, notably in south-west Scotland and south-west Wales. In 1944 the scheme was re-opened to all herds but without financial aid towards testing and without bonus payments. A revised Attested Herds Scheme introduced in 1950 revived the bonus inducement. Bonus on milk sales was paid at a rate of two pence per gallon for four years and a penny per gallon for the following two years whereas owners opting for payment on a capitation basis received an annual payment of two pounds per head and a pound per head over similar periods of time. It is of note that between 1935 and 1950 some 55,000 herds were registered under the voluntary scheme whereas in the subsequent five year period 100,000 herds became attested. This increase in tempo was maintained until the end of the programme.

ERADICATION FROM AN AREA

The Agriculture Act of 1937 gave the Minister of Agriculture authority to spend money on disease eradication and to prescribe areas in which eradication would be obligatory. By 1950 all herds in the Islands of Scilly, Arran, Cumbrae and Shetland had reached attested status by voluntary effort and without further preamble they were declared attested areas by an Order made in February, 1951. A programme of area eradication for the rest of Great Britain was instituted in October, 1950.

The area eradication process was divided into three stages.

(1) *Free testing stage.* Notice was given that compulsory eradication would be introduced in a specified area after a period of two years and that during the two years period stock-owners might have all the tuberculin tests necessary to qualify for bonus payment under the Attested Herds Scheme carried out at the Ministry's expense provided reactors were removed promptly.

(2) *Eradication stage.* Herds not already attested were tested compulsorily and reactors were slaughtered with payment of compensation. Such herds did not receive the bonus payment.

(3) *Attested Area Stage.* When bovine tuberculosis had been reduced to a negligible incidence the area was declared to be an "Attested Area" and disease control measures were enforced by statute.

Before an area was selected for the compulsory eradication of bovine tuberculosis it had to satisfy certain basic demands. It had to be sufficiently large to cause a minimum of interference with normal livestock trading. The area had to be mainly self-supporting in so far as replacement cattle were concerned and marketing facilities within the area and outside the area had to be adequate for the local need. Most important of all and especially in the areas first selected for eradication, a sufficiently high although arbitrary percentage of attested cattle had to obtain.

The stimulus resulting from payment of milk bonus, the propaganda value of tubercle free milk, and the marked economic gain from disease eradication in dairy herds resulted in approximately 80 per cent of the cattle population of south-west Wales and south-west Scotland having reached attested status by 1950. In October of that year these two areas were nominated for the free testing stage of the eradication plan. Of the total population consisting of some 730,000 cattle only 6,000 had not reached the attested standard when the compulsory testing stage was reached. The first compulsory test of the 6,000 cattle revealed 26 per cent reactors but only 2 per cent were found at the second test. Eradication in these areas was complete by 1st April, 1953.

It is of interest that when this initial effort towards eradication was made less than 30 per cent of the national cattle population was of attested status.

The eradication plan was applied progressively to extensions of the original areas and to geographically isolated districts where the voluntary response was thought adequate. The national eradication programme was completed in October of this year. The final area, which included Northumberland, part of Durham, and a broad band of England stretching from Yorkshire to Suffolk in the east and from Lancashire to Stafford in the west, contained two and a half million cattle. When free testing commenced in this area only 54 per cent of the cattle were in attested herds. But an adequate number of tubercle free replacement cattle was already available in the rest of Great Britain and it was obvious that the early removal of infection from this area would benefit the tubercle free herds in the rest of the country.

Records of tuberculin tests carried out during the eradication programme showed that distribution of infection varied widely between different parts of the country—Somerset with 35 per cent reactors at the first compulsory tests of those herds which had not been cleared by voluntary effort; Cheshire with

39 per cent in the first 6 months of free testing; Lanark, Stirling and Dunbarton disclosing 25 per cent during the first round of compulsory tests. All these high-lighted the effect of intensive methods of husbandry and of the flying herd on the health of dairy cattle. In Inverness and Ross (including the Western Isles) only 1·1 per cent reactors was found at the first free test. These highland areas had to a great extent been self-contained, a more extensive system of husbandry had been practised and a much higher proportion of the stock consisted of young animals.

THE ATTESTED AREA

Prior to the introduction of the area eradication plan the attested herd was protected from infection by ensuring a satisfactory physical break between the attested farm and neighbouring holdings carrying untested stock, by controlling cattle movements into the herd and by routine tuberculin testing. The herd was in fact the unit of protection. With the introduction of the attested area the nominated area became the unit, freedom of cattle movement within the area became the rule and restriction was reserved for any essential movements into the area of cattle which were not of attested status and for the occasional herd which produced reactors to the tuberculin test.

Before the advent of the attested area each attested herd was submitted to an annual tuberculin test. If reactors were disclosed they were promptly removed and a further herd test carried out not earlier than 60 days from the completion of the disinfection processes. Should this further test prove clear the herd was next tested after six months interval and if the tuberculin status was again found to be satisfactory the herd reverted to the annual test. After the area reached attested status consideration was given to increasing the interval between tests of all herds which had a satisfactory test history. An interval of two years was thought to be adequate for a first extension. It is obvious that in a region where the initial incidence of infection had been low biennual testing could be introduced more quickly, and that in an area in which a significant proportion of the herds had reached attested status only a short time before the eradication processes had been completed, the test interval could not be immediately extended to two years. Individual herds which for any reason appeared to be in greater risk have continued to be tested annually.

In those areas where biannual testing obtains, an orderly routine of herd-tests is employed and care is taken to ensure that all cattle in large geographical areas are not left for two years without test.

THE ERADICATION PROGRAMME IN RETROSPECT

It is not always clear why some districts made more rapid progress in eradication than others. The rate varied widely not only between areas engaged in differing types of husbandry but within areas in which for the most part a single type of husbandry was practised.

The lack of financial inducement to other than dairy herds in the early

days of Attested Herds Scheme and the low incidence of clinical disease obtaining in the more extensively managed beef herds were no doubt factors responsible for the slow progress in those areas in which beef cattle predominated. It is true that in some parts of Scotland and Wales the incidence of infection was initially low but this however was not the case in south-west Scotland, one of the first areas to reach attested status.

In general it may be said that a modicum of recompense for the financial outlay involved in disease eradication combined with a growing recognition among farmers of the economic gain, not only from a healthy herd, but also from the enhanced market value of attested stock, were the main factors responsible for stimulating the early growth of the scheme. Where a few attested herds were established by progressive farmers a growing number resulted from the example of the few. In time the intensive propaganda campaigns became unnecessary and the voluntary attested herd scheme snowballed under its own momentum.

The introduction of free testing and the knowledge that an area would shortly be scheduled for compulsory eradication resulted in a marked quickening of voluntary effort (Fig. 1).

THE PROSPECT AND PROBLEMS OF MAINTAINING FREEDOM FROM BOVINE TUBERCULOSIS

An incidence of reactors may be expected for many years to come and in fact there is no assurance that the tubercle bacillus can be completely eradicated. The risk of cross-infection from other species of domestic animals is receding. Having broken the cycle of infection at the bovine stage there is

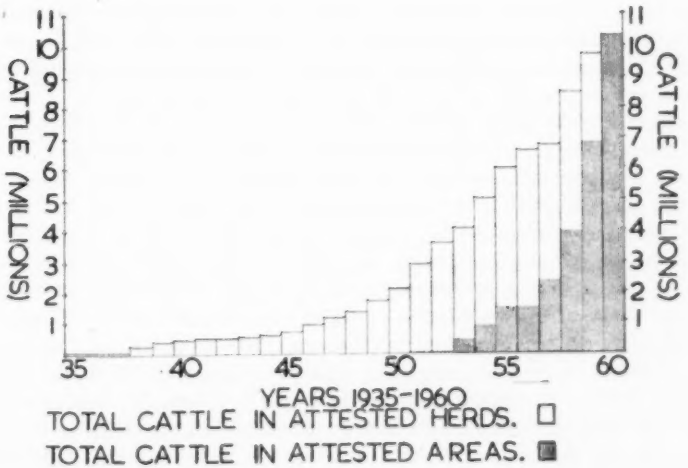

FIG 1
Progress in the eradication of bovine tuberculosis from 1935–1960.

little risk of a reservoir of infection remaining in the pig population for any length of time. Man may continue to constitute a risk to tubercle free cattle. Several instances of cross-infection of bovine type tubercle from man to cattle have already been noted but it is only when a human contact is proved to be an open case that there is acceptable evidence of this source of infection. There is no knowledge of the true incidence of bovine infection from the human source. Human infection would however not appear to be a major hazard.

To date the most frequent cause of massive reinfection in attested herds has been the affected cow with depressed sensitivity. The open lung case if in an extensively managed herd may not infect many other members of the group but in the dairy byre a chain reaction may occur. In the early stages only a few cow-shed contacts may be found positive to the test. Should the infection remain undiagnosed for any length of time however the reactor incidence normally increases and secondary open cases may appear and multiple spread ensue. The test picture was capable on occasion of indicating a possible origin of infection. Batches of reactor calves pointed to infected milk and clinical examination of the milking herd usually detected the affected udder. In adult cattle the primary complex was most frequently found in the respiratory system and, where a high adult incidence obtained, a careful clinical examination of the chest cavity was often rewarding. Major breakdowns in previously clean herds were most commonly due to the affected uterus. Highly infective uterine discharges were responsible for the widespread dissemination of disease and on occasion among all age groups. In the cow-shed the dessicated discharges were responsible for airborne infection, and contamination of utensils and cattle food resulted in primary lesions of the digestive system in batches of cattle which had been husbanded away from the offender. The accidental introduction of disease to a clean herd has been caused by intramammary infusion, obstetrical treatment, subcutaneous injections and the surgical procedures of de-horning and castration. The use of single-dose tubes of intramammary antibiotics, attention to personal hygiene and effective sterilisation of instruments should obviate these catastrophes.

Breakdowns have been noted most frequently in herds which reached attested status by repeated tuberculin testing and in which the original incidence had been high. In due course the undisclosed carrier either dies without having become infective or it is pin-pointed by its clinical condition or by the positive reactions provoked in contact cattle. Every effort must be made however to ensure that a similar sequence is not perpetuated by infected low-allergy contacts of a younger age group, and to this end a strict interpretation of the result of tests of reactor contacts must be maintained. Herds which had been built up by the purchase of young attested stock have to a greater degree remained tuberculin negative. But on occasion farming economy has demanded that cattle which had passed a single tuberculin test should after a period of isolation and further test be allowed to join tubercle free herds. Likewise certain methods of cattle husbandry and the national food requirement will result in the continued importation of once-tested Irish cattle for a limited period. A proportion of these animals may constitute a continuing

hazard because it is certain that many have been in contact with infected cattle at some time in their earlier life.

Be that as it may the programme has resulted in a heavily contaminated national herd of over ten million cattle being cleared of tuberculosis to a point where the average annual reactor incidence for all attested areas during the period January 1955—December 1959 was 0·15 per cent. The average figure over the same period for the 600,000 cattle in the comparatively old established South-West Scotland area was 0·06 per cent and in this area the number of herds in which reactors occurred had dropped from 24 per thousand in 1955 to 9 per thousand in 1959.

THE TUBERCULIN TEST*

Tuberculins and their method of application have suffered many changes since Koch first produced an antigen capable of eliciting an allergic reaction in a tuberculous animal. In the early part of the century "Old Tuberculin" applied by the subcutaneous route resulted in many herds being cleared of tuberculosis. But the subcutaneous test and Old Tuberculin had their limitations. Intradermal-palpebral and ophthalmic methods were employed mainly as adjuncts to the subcutaneous test. By 1930 the subcutaneous test involving the recording of body temperature at 9, 12, 15 and 18 hours after tuberculin injection had been replaced for all tests under the public health legislation by the double-intradermal technique. For the latter a site in the middle of the neck was denuded of hair and a fold of skin measured. Tuberculin was injected into the fold and at the forty-eighth hour after injection the thickness of the fold was again measured. At the same time a second tuberculin injection was made into the same site and a final skin measurement was taken at the seventy-second hour. The result of the test was assessed on the increase in skin measurement from before injection to 72 hours after and on the nature of the reaction. It may be that with the earlier tuberculins the character of the swelling was of some moment but it is doubtful if this is so today and this point will be mentioned later. There has been a continuing effort to produce tuberculins of maximum potency and specificity.

THE SELECTION OF A TUBERCULIN AND THE EVOLUTION OF THE SINGLE INTRADERMAL COMPARATIVE TEST

When the Ministry of Agriculture decided to undertake the preparation of tuberculin for use in connection with the Tuberculosis (Attested Herds) Scheme it selected the Heat Concentrated Synthetic Medium (H.C.S.M.) tuberculin of the United States Bureau of Animal Industry as the type to be manufactured at the Ministry's laboratory at Weybridge. The substitution of a synthetic medium removed the side effects produced by the residual animal protein present in Old Tuberculin. Extensive field trials were carried out, for although H.C.S.M. tuberculin had given satisfactory results in America, it had been applied by the single intradermal caudal fold route, whereas in this country the double intradermal test applied to the neck site was the method of choice. The trials proved the H.C.S.M. product to be more selective than Old Tuberculin in that it produced reactivity in a proportion of affected animals which failed to respond to a simultaneous test using Old Tuberculin. In 1940 Weybridge H.C.S.M. tuberculin was adopted for all official tests. Experience showed that although the new tuberculin resulted in a greater

* Compiled by the staff of the Animal Health Division of the Ministry of Agriculture, Fisheries and Food.

proportional recognition of affected cattle it was equally capable of producing reactivity in a greater number of non-affected animals. It became obvious that the margin of error was significant and that the test and tuberculin could not be accepted as the final answer to the diagnosis of bovine tuberculosis. The problem was one of the specificity. It had already become evident that acid fast organisms other than the bovine type bacillus were capable of provoking tuberculin type sensitivity, the avian type tubercle being particularly responsible for the non-specific reaction to mammalian tuberculin. Faced with this problem the Ministry asked the Agricultural Research Council to investigate the whole question of the tuberculin test with special emphasis on the problem of tuberculin. Preliminary findings were furnished in 1942. These confirmed that Weybridge H.C.S.M. tuberculin was a more satisfactory diagnostic agent than any tuberculin formerly used by the Ministry. From the results of comparisons between Weybridge H.C.S.M. tuberculin and a purified protein derivative (P.P.D.) it was decided however that the P.P.D. tuberculin, which had already been prepared in small amounts at Weybridge, should be introduced as soon as possible.

Tuberculin type sensitivity in cattle was known to be a group sensitivity which might be stimulated by any one of the three types of *Mycobacterium tuberculosis* and by other acid fast organisms. The group sensitivity could be demonstrated in a varying degree by an antigen prepared from any one of the sensitising organisms. Within the group there was no specific response to a homologous tuberculin. But the response was known to be greater to the homologous tuberculin and, having in mind that a high proportion of non-specific reactions were caused by avian type tubercle bacilli, it was decided to introduce a comparative intradermal test. American workers had already recognised two sensitivity sub-groups, one stimulated by human and bovine type tubercle bacilli and for which human type tuberculin was sufficiently specific, and the other produced by avian type tubercle bacilli, *Mycobacterium johnei*, and possibly other related organisms, and for which group avian tuberculin gave the greater response. The use of two tuberculins, avian and mammalian, appeared to be the only practical solution to the problem of non-specific infection, a problem which it was found at a later date would be encountered in 25 per cent of the stock in certain areas.

Following the Agricultural Research Council's pronouncement in 1942, the Ministry's laboratory at Weybridge turned to the preparation of P.P.D. and in April 1943 this was introduced for all official tuberculin testing. Although P.P.D. may not be the final answer it has the merit of being free from the impurities of Old Tuberculin and unlike H.C.S.M. tuberculins it does not suffer from wide variations in quantity of active principle. The double intradermal comparative test involved three visits to the herd and with the rise in the number of herds undergoing test it became obvious that the amount of work would severely tax the available veterinary manpower. Accordingly, an investigation was made into the possibility of using a single intradermal test involving one reading at the seventy-second hour after initial measurement and injection. The experiment was designed to compare the efficiency of the

single intradermal comparative test with that of the double variety. Approximately 10,000 cattle were used in the comparison. Discrepancies between the two tests proved insignificant and it was clear that the single intradermal test had proved as effective as the double. A single injection comparative test using Weybridge P.P.D. tuberculins was introduced in 1947 and remained the diagnostic method of choice throughout the remainder of the eradication programme.

THE TECHNIQUE OF THE SINGLE INTRADERMAL COMPARATIVE TEST

The local response in a sensitised animal to intradermal tuberculin varies with the site of injection. Experience has shown that a region in the middle third of the neck is the site of choice. The hair should be clipped from two areas approximately five inches apart and equidistant from the point of the shoulder. The nature of the local allergic reaction has some bearing on the choice of site for the test. Following the intradermal injection of tuberculin local capillary dilation is followed by extravasation of fluid and leucocytes. It follows that localised areas of chronic dermatitis with marked proliferation of horny cells will either result in the tuberculin being placed in tissue having a meagre blood supply and a consequent inability to produce a true reaction or that the lack of elasticity and even on occasion the cardboard-like texture of the skin will mask the deeper reaction or prevent the skin being folded for measurement. It is important that the texture of the skin should be the same at both test sites.

A fold of skin is picked up over each site and measured with calipers. The operator should attempt to find a suitable caliper tension by adjusting the tension screw. Experience will show that lack of tension will result in movement between withdrawal and reading. On the other hand movement of the caliper arms may require so much effort that diffuse reactions may be constricted through lack of a sensitive caliper response. The comparative test also demands that equal manual tension should be applied to the calipers at both sites.

Avian and mammalian tuberculins in doses of 0·1 ml are injected into the chosen sites and it is advisable to check that a tuberculin "pea" can be detected after injection. The skin fold at each site is again measured at the seventy-second hour and the character of any swelling is noted. The classical reaction is a hard circumscribed swelling which during resolution becomes diffuse. Where the response is marked, cell death may occur and a central zone of necrosis may appear. The latter phenomenon is rarely encountered with modern P.P.D. tuberculins used in the recommended doses. But the onset of resolution may not have taken place by the seventy-second hour and the depth of injection and skin texture may also affect the character of the reaction. The nature of the reaction is not therefore necessarily significant.

THE INTERPRETATION OF THE TUBERCULIN REACTION

No swelling is regarded as negative which in the absence of oedema shows an increase of more than 2 mm. Swellings of 3 mm. increase are regarded as doubtful and 4 mm. or more as positive. A reaction showing the presence

of oedema is regarded as positive no matter how small the increase in measurement.

THE INTERPRETATION OF THE COMPARATIVE TEST

The comparative test requires the further assessment of the specificity of the sensitising agent based on the degree of response to the respective tuberculins.

TABLE 1

Interpretation of tuberculin responses		*Action to be taken: if non-specific infection established in the herd*	*Action to be taken: if non-specific infection not established in the herd*
A+.M–		retain	—
Ao.M–		retain	retain
A+.M+	A greater than M	retain	retest
A+.M+	M not more than 4 mm. greater than A	retain	retest
A+Mo			
Ao.Mo			
Ao.M+			
A–.Mo	M not more than 6 mm. greater than A	retest	retest
A–.M+		retest	remove
A+.M+	M 5 or 6 mm. greater than A	retest	remove
Ao.M+			
A+.M+	M more than 6 mm. greater	remove	remove
Ao.M+			
A–.M+			

THE INTERPRETATION OF THE SINGLE INTRADERMAL COMPARATIVE TEST

A = Avian tuberculin M = Mammalian tuberculin
\+ = positive reaction – = Negative reaction o = doubtful reaction.

The standard interpretation is given in Table 1 and is expressed in terms of whether the animal should be retained in the herd, isolated and subjected to further retest or removed from the herd on account of sensitisation by bovine type tubercle. The standard of assessment is a guide. It is not in itself a complete answer to the problem of specificity but is rather a crystallisation of averages.

Tuberculin type sensitivity varies between individuals and in the same individual at different points in time. Some affected cattle exhibit no detectable sensitivity during long periods of their life. The animal affected with primary uterine or mammary lesions seldom reacts to tuberculin and even where secondary caseating lesions are present the sensitivity is often depressed. The affected animal which has a low allergic response may suffer further depression from the introduction of tuberculin, possibly by antibody neutralisation.

It will be seen that the test is not necessarily specific for the individual but

it is a most useful weapon in the eradication of tuberculosis from the herd. If the tubercle climate of the community is known, a more accurate interpretation of the test of the individual can be made. In herds or herd groups where the standard interpretation of the comparative test points to a significant incidence of bovine type infection the result of the avian test should be waived and the test result based on the response to mammalian tuberculin only.

Evidence of non-specific infection such as a markedly greater response to avian tuberculin or the presence of "skin tuberculosis" or Johne's disease in the herd would influence the action taken in respect of border-line interpretations where the test history of the herd had previously been satisfactory. Animals in this category would be isolated and subjected to further test rather than immediately classified as positive reactors.

With the progressive eradication of bovine tuberculosis from an area the proportion of reactors revealing no visible lesions on slaughter will increase. Examinations carried out *post-mortem* under the tuberculosis eradication plan have been performed on the slaughter-house floor and have necessarily lacked the refinement of a laboratory examination. According to Macrae (1960) 70 per cent of the reactors examined *post-mortem* were reported to have microscopic lesions of tuberculosis. But if it is accepted that the no-lesion reactors which had direct contact with infected cattle were in fact sensitized by mammalian tuberculosis then the figure rises to 80 per cent. Lymph nodes from the respiratory and digestive tracts of reactors with no apparent lesions are normally submitted to the Ministry's laboratories for further examination and Lesslie (1960) states that, to date, bovine type tubercle bacilli have been recovered from 8·5 per cent of the cattle involved.

The phenomenon of tuberculin type sensitivity is not yet entirely understood. It is not certain that a tuberculin of increased potency and specificity would be capable of detecting all affected animals. It may be that some strains of tubercle have low antigenic properties and that individual animals are incapable of producing antibody in any detectable quantity.

References

Macrae, W. D. (1960) *Symp. Zoo. Soc. Lond.* No. **3**. In the press.
Lesslie, I. W. (1960) *Symp. Zoo. Soc. Lond.* No. **3**. In the press.

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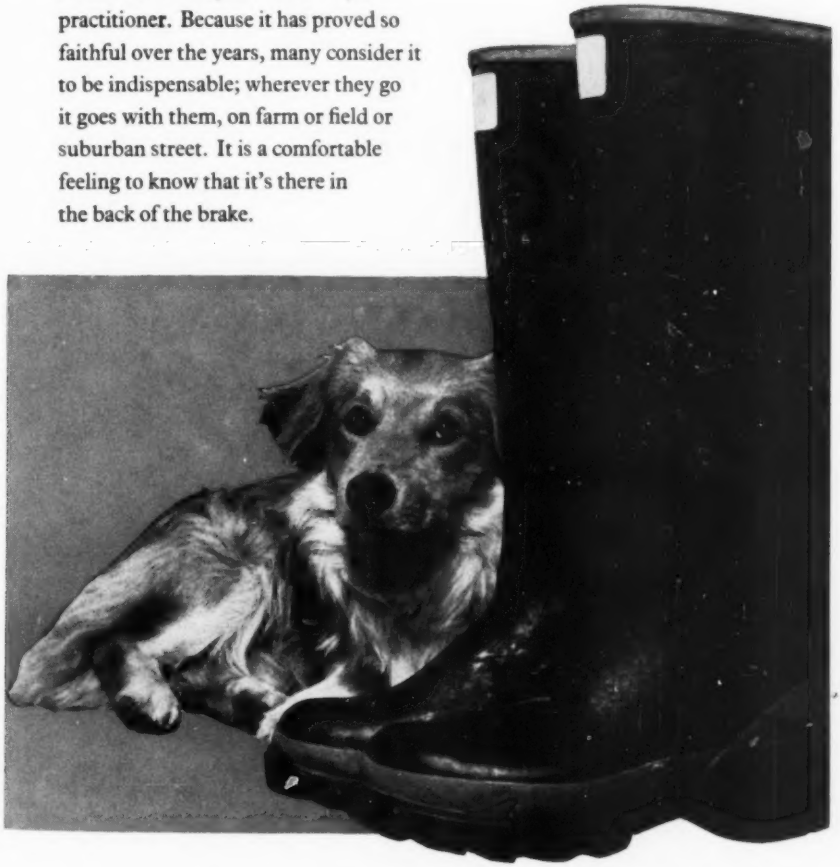

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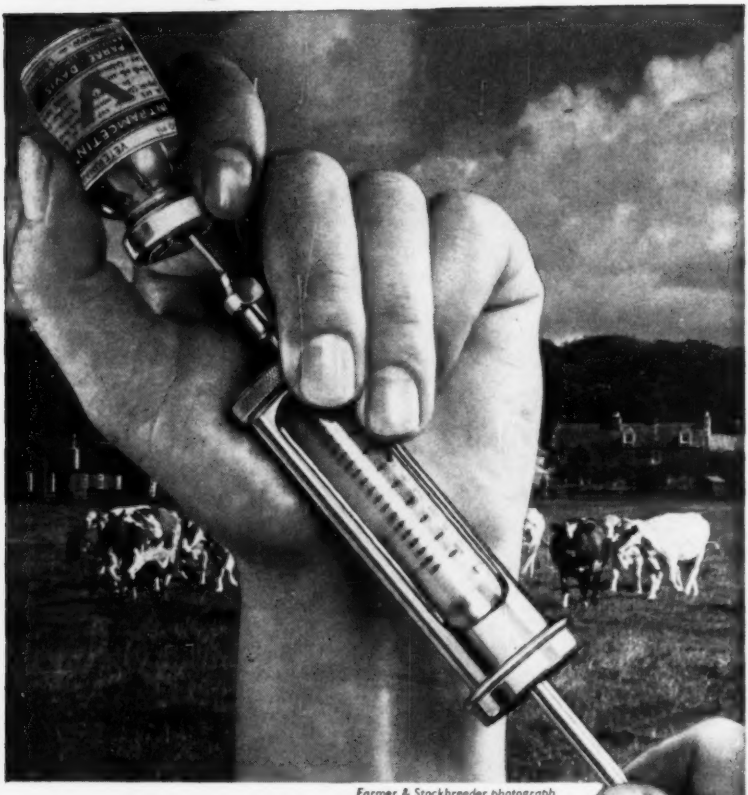

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TUBERCULOSIS IN DOMESTIC ANIMALS OTHER THAN CATTLE*

All species of the domestic animals are susceptible to tuberculosis. The disease is spread among the warm blooded animals from three main sources: man, cattle and birds. Tubercle bacilli do not multiply in nature outside the animal body and so dissemination depends upon the infected contact or upon infected material. The eradication of bovine tuberculosis from the cattle population of Great Britain will eventually remove one source of infection, and will result in a reduction in the overall incidence of the disease in the other susceptible mammals. Meanwhile there is the possibility of reservoirs of bovine infection in other species constituting a potential hazard to cattle. But examination of the incidence would indicate that apart possibly from man there is little risk from this source of infection.

TUBERCULOSIS IN THE HORSE

In the horse the incidence of tuberculosis, based on abattoir returns, is low. According to Glover (1949) during the years 1900–1918 the average figure as disclosed by *post-mortem* examinations was within the range 0·1 to 1·5 per cent. Bywater (1949) records an incidence of three cases in some 80,000 horses sent for slaughter for human consumption in the previous six years, and Grant (1949) reports no cases in 11,544 horses slaughtered in Stirlingshire during 1947–48.

McFadyean (1924) asserted that infection nearly always enters by the alimentary tract, and that the disease is usually acquired through the ingestion of tuberculous milk. In the majority of cases the primary lesions are found in the abdominal cavity and in many are confined to the digestive tract. The abdominal form of the disease is characterised by the development in the mesenteric lymph nodes, spleen and sometimes the liver, of firm greyish white tumour-like growths, which often attain large dimensions, having centres filled with a thick pus-like material; only rarely does partial calcification take place. Prior to McFadyean's work these growths were considered to be lymphadenomata. Occasionally generalisation occurs with miliary tubercles in the lung substance and lesions in the bones, especially the cervical vertebrae, which often results in the horse exhibiting stiffness of the neck and on occasion torticollis. The majority of cases are caused by the bovine type of the bacillus but there are reports of cases caused by the human and avian types. Griffith (1937) summarising the results of 55 cases examined bacteriologically in England, reported that the tubercle bacilli cultivated from these 55 cases

* Compiled by the staff of the Animal Health Division of the Ministry of Agriculture, Fisheries and Food.

belonged to the bovine type in all but two instances, one yielding a strain of human type, the other being avian. He also reported that more than one half were caused by bacilli of low virulence and in his own series of 24 cases he recovered 12 strains fully virulent to guinea pigs and rabbits and 12 of sub-standard virulence varying from slight to considerable. In the case caused by bacilli of human type lesions were found in the spleen, liver and mediastinal lymph nodes and in the lung substance. McFadyean (1918) described a case in which the lesions were confined to the caecum and first part of the colon and resembled those produced in cattle by Johne's Disease. The lesions were rich in acid fast organisms which on culture were found to be avian tubercle bacilli. Werdelin (1925) reported two cases of avian type infection in the horse in which extensive lesions were found in the lungs, liver, spleen and on the pleura and peritoneum.

The disease runs a chronic course and diagnosis on clinical grounds is not always easy, the symptoms being variable and often indeterminate. The use of the tuberculin test as a means of diagnosis is not so accurate as in man and cattle, but little work has been done on determining the most effective method of application or the appropriate dose of tuberculin.

TUBERCULOSIS IN THE SHEEP

The incidence of tuberculosis in the sheep is low. The open air existence and extensive system of husbandry are no doubt contributory factors, but considering the close contact with cattle on many farms there must also be a strong natural resistance. Apart from cases occurring occasionally in pet lambs reared on cows' milk, there is little recorded in the literature. It has been stated by Abbott (1960) that only three affected sheep were found over a period of 25 years in Glasgow Abattoir where approximately 300,000 sheep are slaughtered annually. McFadyean in 1900 recorded the first case in Great Britain and considered it to be of bovine origin. Jowett (1928) recorded two cases found in Edinburgh Abattoir from which he recovered bovine type tubercle bacilli. Griffith (1925) records two cases in which the causal organism was of the avian type, and, in America, Creech (1940) states that out of 60 cases examined in one laboratory only one was of the bovine type and the remainder were avian. Carmichael (1937) reported the investigation of 12 cases in the Ankole area of Uganda where sheep invariably share the huts with the human occupants and found lesions in eleven cases to be due to the bovine and one to the human type of organism. Recently the staff of the Ministry of Agriculture's veterinary laboratory at Lasswade, Midlothian, reported recovering the avian type in material from a generalised case found in a local slaughterhouse.

In the majority of cases the lesions are found in the lungs and associated lymph nodes, but the liver, spleen and mesenteric lymph nodes may also be affected. The lesions are similar to those found in cattle and they readily undergo calcification. Sheep have never presented any problem in connection with the tuberculosis eradication plan in Great Britain.

TUBERCULOSIS IN GOATS

As in the case of sheep, goats apparently have a strong natural resistance to tuberculosis and this probably gave rise to the mistaken belief that they are immune. Goats are not slaughtered for food to any extent in this country and, therefore, no returns are available to give an indication of the incidence of the disease. From continental slaughterhouse returns, however, it would appear to be less than one per cent. There are extremely few reports in the literature on outbreaks of naturally acquired infection in goats; Griffith (1917) recorded a case where the bovine type bacillus was found in a young goat reared on cows' milk and Little (1924) recorded a case in a young goat reared partly on goat and cow milk. Carmichael (1937) recorded 11 cases of tuberculosis in goats all due to the bovine organism. Soliman, Rollinson, Barron and Spratling (1953) recorded an outbreak in a herd of goats in which 41 were examined. Macroscopic lesions were found in 32, of which two had indurated udders and the associated lymph nodes showed caseating areas. An outbreak in a herd of 109 goats in Tanganyika in which six adult goats reacted to single intradermal comparative test using Weybridge P.P.D. tuberculins has been reported by Milne (1935). At autopsy all six showed lesions mainly confined to the respiratory tract and the biological findings were indicative of bovine infection. The goats had been enclosed at night with cattle, some of which were found to be affected with tuberculosis and Milne suggests the goats contracted the disease from the cattle by inhalation. Goats were kept in close contact with cattle on many farms in this country on the widely held belief that they prevented outbreaks of contagious abortion. There are very few known instances of their reacting when tuberculin tested along with the cattle and even fewer of their being responsible for the reintroduction of infection in tubercle free herds.

The disease follows the usual chronic course associated with tuberculosis, and apparently healthy animals often show extensive lesions on *post-mortem* examination. In kids the disease is sometimes rapidly progressive and causes death at an early age. While susceptible to the bovine type bacillus the goat appears to be practically immune to natural infection by the human and avian types. The lesions found are similar in character to those in the bovine, Lesions of the respiratory tract are most frequently encountered but primary ulceration of the intestines has been noted. The tuberculin test as an aid to diagnosis, especially the single intradermal comparative test, appears to be more reliable in the goat than in any species apart from the bovine.

TUBERCULOSIS IN THE PIG

The incidence of tuberculosis in swine is higher than in the other species because the pig is more susceptible to natural infection by all three types of the bacillus. Ellison (1930) found that of 72,350 pigs slaughtered in an Ipswich bacon factory 12·09 per cent were affected; Anthony (1950) records that of two and a half million pig carcases of all ages from various parts of the British Isles, 11 per cent were found to have lesions of tuberculosis. In New Zealand, Hankin (1937) reported up to 20 per cent tuberculosis infection in pigs examined

at export factories and Miller (1958) records that of 4,360,719 pigs examined in America in 1920, 11·16 per cent were affected, and in 1948 of 2,968,631 examined, 6·11 per cent were affected. Miller's figures are of interest because his comparable figures for bovines are 2·05 per cent and 0·18 per cent from which it is apparent that the eradication of tuberculosis from cattle in America has not resulted in a comparable fall in the incidence in pigs. This Miller attributed to the high incidence of avian tuberculosis then obtaining in America. Griffith and Griffith, working for the Royal Commission on Tuberculosis, obtained cultures from 59 tuberculous pigs and found 50 were of the bovine type, five avian type, three human type and in one both avian and bovine types were found. Eastwood and Griffith (1914) investigated 78 cases of tuberculosis and found 49 yielded bovine type cultures, 20 avian type cultures and one human type culture, and in the two remaining cases found one infected with bovine and avian types and the other with bovine and human types. Thornton (1949) estimated that two-thirds of the cases in pigs were due to the bovine type infection and one-third to the avian type, and Lesslie (1959) recorded that in material from 64 pigs from various parts of England and Wales, 44 (69 per cent) were infected with the avian type and the remainder with a bovine strain. This swing from bovine to avian type infection indicates, as does the noticeable decline in the number of pigs found affected with tuberculosis in slaughterhouses, the progress of the cattle tuberculosis eradication plan and its effect on other species. The progress is well illustrated in the following percentages, compiled from returns, of the total, partial, and head condemnations in pigs found affected with tuberculosis in Glasgow Abattoir (Abbott, 1960); in 1904—3·9; in 1914—3·03; in 1935—3·4; in 1945—2·2; in 1955—0·4; and in 1959—0·25. Figures which show a similar pattern come from Dundee, although percentages are slightly higher namely in 1935—2·1; in 1945—2·4; in 1955—0·66; and in 1959—0·32 (Spreull 1960). The slightly higher percentage is probably due to the north-east of Scotland, a beef cattle area, being ten years behind the west of Scotland, a dairying area, in the eradication of tuberculosis from cattle.

Infection is mainly by ingestion, and in the past tuberculosis was most frequently observed in pigs from dairying districts where the feeding of skimmed milk and whey was a common practice. Other sources of infection are cow dung, slaughter-house offal and droppings of infected poultry. Infection by inoculation can occur as instanced by the findings of primary lesions on the spermatic cords of castrated pigs.

The alimentary tract being the usual route of infection the common sites of lesions are the submaxillary, cervical and mesenteric lymph nodes; the bronchial and mediastinal nodes may also be involved. Disease is usually of a localised nature but generalisation does occur, especially in the case of bovine type infection. The lymph nodes in avian and human type infections are not appreciably enlarged and contain discrete caseo-calcareous tubercles not unlike grains of sand, whereas with the bovine type the nodes are usually enlarged and composed either wholly or in part of caseous or caseo-calcareous material surrounded by fibrous tissue. Lesions are found in the liver, spleen,

lungs, bones and the central nervous system. Those found in the liver caused by the bovine type of infection are usually small in size, being little larger than a pin head, often encapsulated and tending to undergo caseation and calcification, while the avian type gives rise to a proliferative type of lesion not unlike the "milk spots" caused by migrating parasites. In the spleen in bovine type infection the lesions may be large and project above the surface of the organ. In the avian type the organ may be enlarged and the lesions are frequently pink or grey in colour and of a tumour-like consistence and may show a central depression. The lung lesions caused by the bovine type have caseous and calcified nodules, whereas, in the avian type caseation or calcification rarely occurs, the lesions being minute and distributed throughout the lung substance. Lesions in the bones are mostly found in the vertebrae, especially those of the lumbar region.

Few pigs show clinical symptoms during life apart from slight digestive disturbance with loss of condition, or in the case of lung infection, symptoms of progressive pneumonia.

Clinical diagnosis is difficult, the symptoms being similar to those encountered in other common ailments of the pig. The comparative intradermal tuberculin test using either avian or bovine tuberculins is widely used in breeding herds and it is now common practice for owners to advertise and sell their stock as tuberculin tested.

TUBERCULOSIS IN DOGS AND CATS

The close relationship existing between dog, cat and man raises a public health as well as an animal health problem. Although the hazard is small, domestic pets may continue to act as a reservoir of tuberculosis for man. Lovell and White (1940) report that of 543 canine autopsies tuberculosis was found in 4·6 per cent, Jennings (1949) records that of 165 dogs autopsied in Liverpool 6·8 per cent were affected with tuberculosis, and Hawthorne, Jarrett, Lauder, Martin and Roberts (1957) record that of 175 consecutive canine autopsies over a period of four months in Glasgow 4·5 per cent had generalised tuberculosis. In the cat, Dobson (1930) recorded finding 11 cases out of 505 *post-mortems* (2·1 per cent) and Lovell and White (1940) gave a figure of 3·6 per cent. The dog is susceptible to infection with both the human and bovine types of the tubercle bacillus and Moltzen-Nielson and Plum (1943), who surveyed the literature, noted that 70 per cent of the cases were due to the human type, 27 per cent to the bovine type, 0·5 per cent to the avian type and 2·0 per cent were atypical. In the cat infection is invariably due to the bovine type and, with the elimination of tubercle from the milk supply, tuberculosis in the cat should rapidly disappear.

The disease in the dog does not, as is generally believed, run a rapid course accompanied by emaciation; on the contrary, affected dogs are often in good bodily condition and asymptomatic although active disease may be of long standing.

The dog is subject to airborne infection from the human and the primary

complex is most frequently found in the respiratory system. In the cat the alimentary tract almost invariably is the primary seat. In the dog the lungs and associated lymph nodes together with the pleura and pericardium are most commonly affected. Lesions may be found in the liver, kidneys and mesenteric nodes and are commonly due to haematogenous spread or ingestion of tracheal mucous. Infection of the serous membranes is much more common in the dog than in the other species. In the cat, lesions are mostly confined to the intestines and mesenteric lymph nodes and ulceration of the intestines is common in the cat and rare in the dog. The disease sometimes takes a cutaneous form either of ulceration of the skin of the face and neck or of subcutaneous swellings, usually in the submaxillary region, which often discharge through a sinus. Jarrett and Lauder (1957) report that in the dog, lesions are most commonly found in the broncho-mediastinal lymph nodes with or without obvious pulmonary involvement. The nodes may be enlarged up to 3 to 4 inches in diameter and may be firm and fibrous or show central necrosis and cavitation. They emphasise that the typical yellow caseation of the bovine disease is seldom found in the dog and that lesions are often misdiagnosed as neoplasia.

The lung lesions may take the form of small greyish white nodules in the substance, or larger areas of broncho-pneumonia which may break down with the formation of cavities. The pleural and pericardial lesions are invariably exudative, giving rise to the collection of considerable quantities of fluid which in some cases cause collapse of the lower portions of the lungs. In the liver the lesions may be small multiple greyish nodules scattered throughout the substance or larger lesions with soft purulent centres. In the kidneys the lesions vary from miliary size to almost complete replacement of the cortical substance. Jarrett and Lauder (1957) point out that examination of a culture from the deposit of centrifuged urine is one of the most valuable tests for clinically silent tuberculosis, and also draw attention to two disease syndromes which should always arouse suspicion of tuberculosis in the dog namely renal amyloidosis and Marie's disease or hypertrophic pulmonary osteo-arthrophy.

As a means of diagnosis the tuberculin test is unreliable in the dog.

References

Abbott, S. G. (1960) *Personal communication.*

Anthony, D. J. (1950) *Diseases of the Pig and its Husbandry.* 3rd Edition. London: Baillière Tindall & Cox

Bywater, H. E. (1949) *Vet. Rec.* **61,** 8.

Carmichael, J. (1937) *J. comp. Path.* **50,** 383.

Creech, G. T. (1940) *Amer. J. vet. Res. I.,* 23 *Cit. Vet. Rec.* **54,** 83.

Dobson, N. (1930) *J. comp. Path.* **43,** 310.

Ellison, G. (1930) *J. roy. san. Inst.* **50,** 669.

Glover, R. E. (1949) *Vet. Rec.* **61,** 875.

Grant, W. (1949) *Vet. Rec.* **61,** 41.

Griffith, A. S. (1917) *J. comp. Path.* **21,** 342.

Griffith, A. S. (1925) *Ibid.* **38,** 157.

Griffith, A. S. (1928) *Ibid.* **41,** 110.

Griffith, A. S. (1937) *Ibid.* **50,** 159.

Hankin, T. H. (1937) *Aust. vet. J.* **13,** 241.

HAWTHORNE, V. M., JARRETT, W. F. H., LAUDER, I., MARTIN, W. B., & ROBERTT, G. S. B. (1957) *Brit. med. J.* **2,** 675.
JARRETT, W. F. H., and LAUDER, I. (1957) *Vet. Rec.* **69,** 932.
JENNINGS, A. R. (1949) *Vet. Rec.* **61,** 380.
JOWETT, W. (1928) *J. comp. Path.* **41,** 255.
LESSLIE, I. W. (1959) *Brit. med. J.* **31,** 59.
LITTLE, W. L. (1924) *Vet. J.* **80,** 371.
LOVELL, R. & WHITE, E. G. (1940) *Brit. J. Tuberc.* **34,** 117.
MOLTZEN-NIELSEN, H. & PLUM, N. (1943) Maanedsskr. Dyrlaeger, **54,** 201–213. *Cit. Vet. Bull.* (1947) **17,** 306.
MCFADYEAN, J. (1900) *J. comp. Path.* **13,** 59.
MCFADYEAN, J. (1918) *Ibid.* **31,** 225.
MCFADYEAN, J. (1924) *Ibid.* **37,** 44.
MILLER, A. R. (1958) *Meat Hygiene.* London: Henry Kimpton.
MILNE, A. H. (1955) *Vet. Rec.* **67,** 374.
SOLIMAN, K. N., ROLLINSON, D. H. L., BARRON, N. S., & SPRATLING (1953) *Vet. Rec.* **65,** 421.
SPREULL, A. (1960) *Personal communication.*
THORNTON, H. (1957) *Textbook of Meat Inspection,* 3rd ed. London: Baillière Tindall & Cox.
WERDELIN (1935) Maanedsskr. Drylaeger. **47,** 81. *Abstract in Vet. Bull.* **6,** 488.

AVIAN TUBERCULOSIS

An Account of the Disease in Poultry, Captive Birds and Wild Birds

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The separate nature of human, bovine and avian tuberculosis was stated by Professor Koch on 23rd July, 1901 in an address to the Second General Meeting of the British Congress on Tuberculosis. In a lengthy dissertation he dismissed the avian disease rather summarily. "The tuberculosis of poultry however differs so much from human tuberculosis that we may leave it out of account as a possible source of infection for man". Previously he had considered the causative organism of the avian disease "In a way nearly related to the real tubercle bacilli".

Although Koch's assessment of the importance of avian tuberculosis in man proved to be correct, the disease has been of much consequence in poultry, and to a lesser extent other livestock, in many parts of the world.

Important as Koch's work on tuberculosis was, he was not the first to describe the disease in fowls. This must be credited to Dr. Crisp in a report to the Pathological Society of London in 1868, concerning hens which he had brought from Cheshire and kept in a damp sheltered corner of his garden. After a few months they became emaciated and "The livers and spleens were enlarged and tuberculated as was also the peritoneal surface of the intestines". Later Crisp (1872) demonstrated to the Society the bodies of five tuberculous hens which had shown symptoms of failing appetite, gradual wasting and diarrhoea with lesions in the liver, spleen, mesentery and joints. He considered the disease contagious and thought "That birds confined to ill-ventilated enclosures where others had been affected were liable to take the disease". This succinct description of the disease of 90 years ago, before its essential nature had been recognised is an excellent summary of the disease as it exists today. The first record of avian tuberculosis in Scotland appears to be that of Hebb (1888) and concerned fowls from a farm near Glasgow; the history supplied by the owner was that "The birds were dying of some wasting disease and that the liver was the part most affected". The disease was recorded in Ireland a year later (Cameron, 1889).

Crisp (1872) also appears to have been the first to describe tuberculosis in birds other than fowls when he recorded the disease in 21 two-year-old pheasant hybrids (common pheasant X Chinese ring-neck). Sutton and Gibbs (1884)

described an outbreak of avian tuberculosis on a farm in Middlesex in which all the older birds died. Restocking with young birds produced satisfactory results at first but the following year losses again occurred. Ducks and geese remained unaffected. The authors also drew attention to tuberculosis in other avian species; following the examination of over 1,000 birds, including wild birds and birds from the Zoological Gardens the disease was found in pea fowl, guinea fowl, pigeon, partridge, grouse, pheasant, storks and cranes and in a falcon and an eagle. The disease in the two latter species was attributed to their having fed on smaller affected birds.

Another excellent early description, illustrated by several sketches, of the disease in fowls and other birds is provided by Sibley (1890). He was interested in the possibility of its spread by wild birds and examined sparrows and starlings from infected premises for six or seven years without finding any evidence of infection in them. He recorded the disease in geese, pheasants, swans, pea fowl, pigeons, doves, canaries, finches, owls and vultures.

For many years after its discovery, avian tuberculosis was confined to flocks on general farms and to fowls kept in backyards or gardens. The birds were usually retained for many years, long after their economic period of egg production had passed. In the former environment they tended to congregate in the farm-yard around the farm buildings and dung heap and roosted in stables, cart sheds or fixed poultry houses. The garden runs and yards were usually small and over crowded and in continuous use for many years. The disease continued to occur under these conditions and still does, but now only very rarely.

When a specialised poultry industry came into being after the first World War the semi-intensive system of poultry keeping was largely employed. Many of the new farms were situated in urban areas and the available land was strictly limited. Poultry runs were in continuous use and overstocking was common; under these conditions tuberculosis became increasingly common.

It was the general custom to introduce fresh blood by purchasing cockerels from established pedigree breeding farms. These also operated on the semi-intensive system and often the purchased birds were already infected and were a common means of spreading the disease. During the period 1913 to 1933 Matheson and Wilson (1933) noted that avian tuberculosis was the commonest finding in birds sent for diagnosis from various parts of Scotland and represented almost 14 per cent of all specimens and double the number of cases of leucosis (6·5 per cent). Neurolymphomatosis, which has always been regarded as a separate disease from leucosis was not recorded in Scotland until 1931 and during the last two years of the survey its incidence was insignificant.

The sweeping changes in methods of poultry keeping have had a marked effect on the incidence of avian tuberculosis and with the increased use of intensive methods, notably the battery and deep litter systems, its prevalence has decreased greatly. The emphasis on disposal of commercial laying stock at the end of the first laying year or, if not, at the end of the second year at the latest has also had a marked effect.

The dwindling incidence of the disease is shown in Table 1, which also reveals

a significant difference in the number of positive cases from accredited and non-designated flocks. The reduction in accredited specimens would appear to be the result of the ready availability of laboratory services to participants in the Scheme, making possible an early diagnosis, combined with on-the-spot advice and help from members of the field staff of the Animal Health Division of the Ministry of Agriculture, the prompt institution of control and preventive measures and the maintenance of an effective standard of husbandry, under the general supervision of National Agricultural Advisory Service.

TABLE I—PERCENTAGE INCIDENCE OF AVIAN TUBERCULOSIS IN SPECIMENS FROM ACCREDITED AND NON-DESIGNATED FLOCKS FROM 1940 TO 1949

	Accredited per cent	*Non-designated* per cent	*Combined* per cent
1940	8·5	—	—
1941	10·1	10·5	10·3
1942	6·3	6·7	6·2
1943	5·1	6·9	6·1
1944	4·1	5·5	4·6
1945	3·7	5·4	4·3
1946	2·8	3·8	3·1
1947	3·2	6·2	4·4
1948	2·4	6·6	4·1
1949	2·6	5·6	4·2

The increased incidence of the disease in accredited specimens in 1942 coincided with a great influx of flocks, previously outside official control, under the Preferential Feeding Stuffs Scheme.

The comparative incidence of tuberculosis and other common diseases of poultry is shown in Table II. It will be noted that during the period of ten years, covered by the table, the overall incidence fell from 3·2 per cent in 1950 to 1·4 per cent in 1959, the lowest figure recorded during the 47 years for which records are available; only 171 of nearly 12,500 specimens were affected. The position has been maintained during the first six months of 1960 with an incidence of 1·6 per cent. When the overall figures for 1959 and 1960 are broken down the incidence of the disease in specimens from accredited farms is 0·3 and 0·4 per cent and from non-designated farms 1·8 and 2·1 per cent respectively. These show proportionally a much greater reduction in infected material from accredited flocks; the respective figures for accredited and non-designated flocks in 1941 were 2·6 per cent and 4·2 per cent.

THE IMPORTANCE OF THE DISEASE

Avian tuberculosis is a serious source of economic loss to the poultry industry on account of increased mortality and morbidity and diminished egg production. It is also a common cause of death in birds in zoological gardens.

It is of importance in cattle, primarily on account of sensitisation to the tuberculin test and less commonly through progressive disease. The role of the avian organism in the etiology of porcine tuberculosis has long been recognised; in some parts of the world it causes disease in sheep and more rarely in other animals.

TABLE II—ANALYSIS OF SPECIMENS RECEIVED FOR POST-MORTEM EXAMINATION
1950 to 1959

Year	*Number of Birds*	*Fowl Paralysis*		*Leucosis*		*Osteopetrosis*		*Tuberculosis*		*Tumours*		*Escherichia coli Granuloma*	
		Number	*per cent*	*Number*	*per cent*	*Number*	*per cent*	*Number*	*per cent*	*Number*	*per cent*	*Number*	*per eent*
1950	4,695	614	13·1	655	13·9	8	0·2	150	3·2	383	8·1	101	2·2
1951	5,409	637	11·8	697	12·8	12	0·2	150	2·8	339	6·2	154	2·8
1952	5,887	658	11·2	633	10·8	15	0·3	159	2·7	335	5·7	73	1·2
1953	6,937	1,000	14·4	645	9·3	9	0·1	183	2·6	396	5·7	79	1·1
1954	6,934	963	13·9	625	9·1	7	0·1	174	2·5	385	5·6	110	1·5
1955	8,057	1,043	12·9	621	7·7	7	0·08	165	2·0	379	4·7	96	1·2
1956	10,583	1,426	13·5	1,164	10·9	14	0·13	194	1·8	426	4·3	196	1·9
1957	10,527	1,355	12·9	1,114	10·5	10	0·09	200	1·9	354	3·3	213	2·2
1958	10,014	1,487	14·8	816	8·1	18	0·17	220	2·2	304	3·3	245	2·4
1959	12,427	1,933	15·6	1,142	9·1	13	0·11	171	1·4	387	3·1	231	1·9

DISTRIBUTION AND INCIDENCE

Avian tuberculosis has a world-wide distribution. According to Feldman (1959) it occurs more frequently in the north temperate zone than elsewhere. The position in Britain has been discussed already. The disease appears to be present in most European countries; it is believed to be infrequent in Switzerland, rare in Italy, almost unknown in Greece, and to have assumed serious proportions in certain of the Balkan States (Feldman, 1959). It was first recognised in the U.S.A. about 1900 but was not considered to be prevalent until 1920 when a survey showed it to exist to an alarming degree in the corn belt, where the poultry population was most dense. There was little in the eastern states or on the west coast. The disease was worst in farm flocks where birds were kept until they were two, three or four years old. Large commercial poultry flocks where birds were rarely kept after they were 18 months old were relatively free (Johnson and Ranney, 1956).

Feldman (1959) considers that the present overall incidence of the disease in U.S.A. is probably less than 5 per cent. The percentage of flock infection is estimated at between 50 and 65 in the heavily infected north central states and negligible in the southern and western states. The infection rate in individual flocks varies from less than 5 per cent to as much as 90 per cent. Data quoted by Feldman show that the incidence of the disease has fallen very greatly during the last 32 years. During that time approximately 3·4 million flocks were tuberculin tested and the average incidence of flock infection dropped from a high of 7·0 per cent in 1928 to a low of 0·6 per cent in 1956.

Although avian tuberculosis is still an important disease in U.S.A., and in 1954 was estimated to cause a financial loss of 3 million dollars annually, figures in Table III show that this is only one twentieth of the estimated loss from lymphomatosis, one eighth that from Newcastle disease, a third that from C.R.D. and two-thirds that from bluecomb.

TABLE III—LOSSES TO FOWLS CAUSED BY DISEASE.

Figures taken from "Losses in Agriculture", published by United States Department of Agriculture (1954)

Disease	*Loss in Value*		*Loss in Quantity*	
	Amount in 1,000 dollars	*Per cent of Potential value*	*Number (1,000's)*	*Per cent of Potential Production*
Tuberculosis	3,000	0·10	2,400	0·13
Fowl Cholera	8,064	0·28	6,342	0·34
Fowl Typhoid	6,514	0·22	5,837	0·31
Fowl Pox	1,239	0·043	875	0·047
Newcastle Disease	24,012	0·82	45,822	2·43
Infectious Bronchitis	7,055	0·24	12,450	0·67
Infectious Laryngo-Tracheitis	4,848	0·17	6,014	0·33
Air Sac Infection	9,696	0·33	14,749	0·79
Blue Comb	4,377	0·15	3,113	0·17
Lymphomatosis	65,000	2·18	43,000	2·28

Total annual production 1,842,192,000 birds
Value 2,909,334,000 dollars.

In Canada the incidence of the disease appears to vary greatly in the different provinces; it is said to be low in South America (Feldman 1959) and has been described in Australia by Edgar (1950) and Robin (1950).

AVIAN TUBERCULOSIS IN THE DIFFERENT SPECIES

The Fowl

The chronic insidious nature of the disease allows it to become well established before its presence is suspected and often by the time symptoms are noted and deaths occur, a high proportion of the flock is affected. In the early stages no symptoms may be evident, but where trap nesting is carried out, an owner when handling the trapped birds may notice a loss of condition in some of them.

Later there is reduced activity, more rapid wasting and often diarrhoea. The comb and wattles become smaller and shrivelled and the feathers dry and ruffled. Appetite is usually good but may become capricious. Some birds in the flock may show lameness. As the disease progresses an increasing number of deaths occur at ever-shortening intervals; usually the dead birds are in poor to emaciated condition but deaths of birds in prime condition are not uncommon. Young birds are more susceptible to the disease but the highest mortality occurs in the older age groups. The proportion of affected birds varies greatly on different farms; when the disease occurs in young stock and is detected early, as few as 2 to 5 per cent may be infected, but on farms where losses have been occurring for some time, up to 70 per cent or more reactors have been found. The infection rate of similar age groups in different pens may vary within very wide limits; from 0 to 70 per cent has been recorded (Wilson 1940).

Post-mortem Appearance

Bodily condition varies from prime condition to gross emaciation. Loss of breast flesh is particularly marked; in extreme cases there may be complete atrophy of the sternal muscles. The liver, spleen and intestines are most commonly affected.

The liver is usually enlarged, sometimes markedly so. A few or many yellowish-white discrete nodules may be present, varying in size from a pin head to a pea. They can be shelled out readily from the substance of the liver and do not normally project much, if at all, above its surface. Sometimes several nodules coalesce to form a tuberculous mass. There may be evidence of internal haemorrhage from rupture of the diseased liver. Matheson and Wilson (1933) recorded this in almost 5 per cent of their cases.

The spleen is usually enlarged, sometimes to a massive extent and studded with protruding whitish yellow nodules. In advanced cases almost the entire splenic tissue may be replaced by caseous material. Lesions in the intestines vary greatly in number and size. They may be few and small, pin head to millet seed in size or up to the size of a golf ball or larger. They are often

confined to the caeca and adjacent parts of the intestine, or they may be numerous and present along its entire length.

The lungs are less commonly affected. Wilson (1940) recorded 18 per cent of positive cases. Lesions may be small but are more usually large and several may coalesce and replace much of the lung tissue. There is a suggestion that in some more recent outbreaks in deep litter the infection rate in the lungs is much higher.

Gross evidence of ovarian infection is relatively rare but is noted from time to time. There is a high rate of involvement of the bone marrow even in relatively early cases of the disease. An examination of the tibiae and femora of 180 tuberculous fowls showed lesions in the bone marrow in 70 per cent (Wilson, 1940). The joints are less commonly affected. The thymus was found to be affected in 27 per cent of the same series and White and Ellis (1939) reported an incidence of 20 per cent in cases of generalised tuberculosis condemned at meat inspection.

There is a remarkably low level of helminth infestation in birds affected with tuberculosis. In the advanced disease worms may be completely absent and when a fair number of worms occur the disease is invariably at an early stage (Morgan and Wilson, 1938).

"Bumble foot" which was once popularly considered to be a form of tuberculosis is rarely caused by *Mycobacterium tuberculosis avium*. Bunyea (1936) found suggestive acid-fast organisms in 45 of 76 cases but attempts at cultivation were unsuccessful and microscopical examination of the affected tissues showed none of the general characteristics of tuberculosis.

It is necessary to distinguish the lesions of avian tuberculosis from the granulomatous lesions sometimes present in fowls, chiefly in the caeca and adjacent parts of the intestine, less commonly scattered throughout the intestines, and still more rarely in the liver and spleen. The granuloma vary in size from quite small to massive and while they resemble avian tuberculosis in gross appearance they are markedly different microscopically. The caseous contents of the granuloma are more waxy than tuberculous material and when preparing a film are not as readily miscible with water. The condition is not uncommon in fowls, in fact during the last four years it has been recorded more often than avian tuberculosis in material received for *post-mortem* examination (Table II). The disease has been recognised for many years; the writer who had collected material for nearly ten years drew Slavin's attention to it in 1937 and he showed that it represented a localised *Escherichia coli* infection. The results of the investigation were never published as at the time they seemed insufficiently important and not of much general interest but the condition has always been known to us as Slavin's disease. A similar condition was described by Magnusson (1945) and Hjarre and Wramby (1945) and it is usually referred to in the literature as Hjarre's disease.

Turkeys

Turkeys are susceptible to tuberculosis but outbreaks are rare. Almost invariably initial infection is acquired through contact with tuberculous fowls. Once

PLATE I

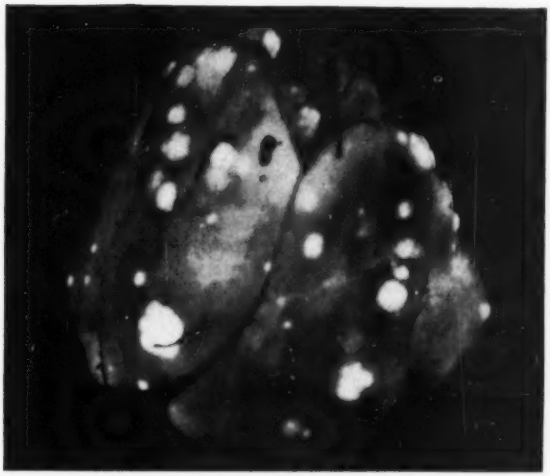

FIG. 1. Tuberculosis of liver of turkey showing great variation in size of tuberculosis nodules.

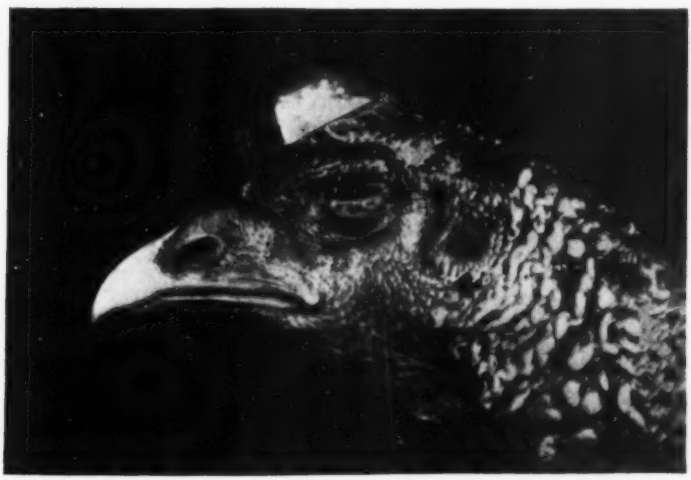

FIG. 2. Head of turkey with tuberculous nodule, incised to show its caseous nature.

PLATE II

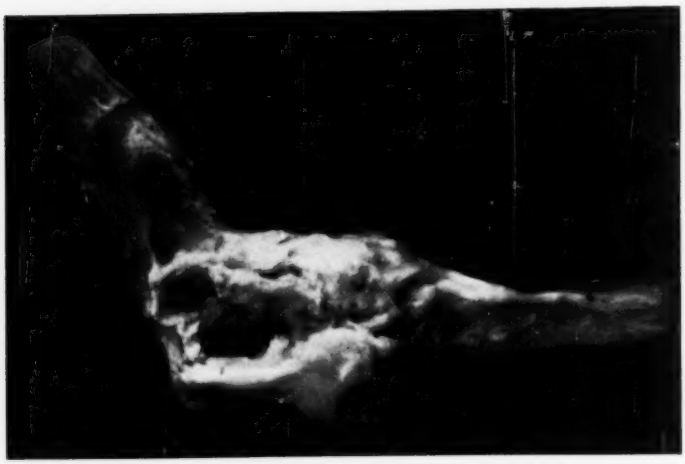

FIG. 3. Tuberculous stifle joint of fowl in which there was also extensive bone marrow involvement.

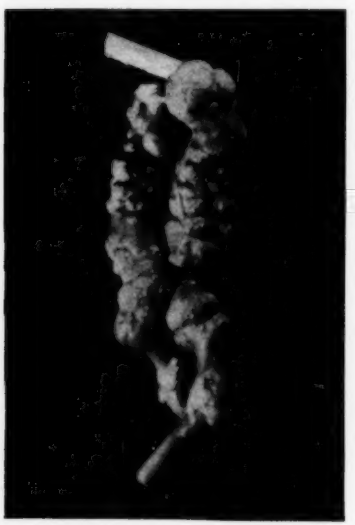

FIG. 4. Caeca of fowl with *E. coli* granulomata.

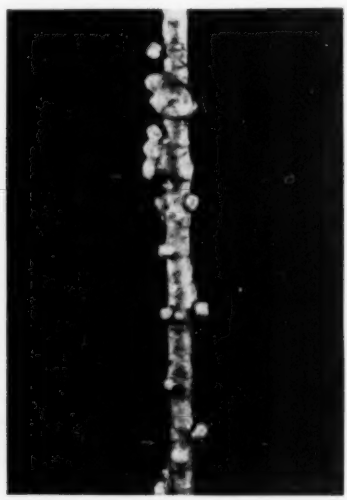

FIG. 5. Ileum of fowl with multiple *E. coli* granulomata present throughout the intestines.

introduced into a turkey flock the disease may persist for many years; in one Scottish flock cases have occurred intermittently since 1945. The disease is essentially similar to that in fowls with lesions chiefly in the liver, spleen and intestines. In some advanced cases lesions in the liver may reach an inch or more in diameter and there is often very massive involvement of the lungs. Lesions in the form of large subcutaneous nodules have been noted over the breast and on top of the skull, at the latter site giving the turkey a helmeted appearance (Wilson, 1945). Skin lesions have also been described by Lerch (1931).

Ducks

Tuberculosis is relatively rare in ducks and while isolated cases are received from time to time only one small-scale outbreak has been recorded in Scotland. Feldman (1938) considers the disease to be generally uncommon in water fowl and that ducks even in close association with tuberculous fowls are seldom affected. Craig and Davies (1937) reported a small outbreak in which 13 of a flock of 15 ducks were affected and an extensive outbreak was described by Gordon, Garside, Dobson and Reid (1941) who found the disease in 29 or 25·8 per cent of 113 ducks selected at random from a duck breeding farm with approximately 25,000 head of stock. They considered that these figures gave a reasonable indication of the incidence of the disease in the flock. An outbreak of tuberculosis in ducks in India was described by Zargar (1946). The chief difference in the disease in ducks is the relative frequency of lung, air sac and peritoneal involvement. Figures provided by Gordon *et al.* (1941) showed lesions in the liver 75·8 per cent, spleen 41·3, intestine 20·6, lungs 68·9, clavicular air sac 41·3, thoracic air sac 20·6, peritoneum 31·0.

Geese

The disease appears to be rare in geese; neither Feldman (1938) nor Francis (1958) give references to any recorded cases. Tereshchenko (1957) tested 765 geese on ten farms by the double intradermal tuberculin test and found 232 reactors. All had lesions in the liver or liver and intestines but generalised tuberculosis was rare.

Captive Birds

Tuberculosis is a common cause of death in birds in captivity and there are records of its occurrence in almost every variety kept. Between 1927 and 1930 the writer recorded the disease in a guinea fowl, peacock, grey plover (*Squatarola squatarola*), green plover (*Vanellus vanellus*), golden plover (*Pluvialis apricaria*), egret, knot (*Calidris canutus*), hornbill, parrot, black headed ibis, golden eagle (*Aquila chrysaetus*) and several species of pheasant. Human tuberculosis was also diagnosed in a parrot.

Once the disease occurs in an enclosure it is difficult to control as it is usually impossible to provide alternative accommodation and all the occupants may ultimately succumb. In one aviary an entire group of seven black headed ibis

died from the disease within a period of ten months and a pen of four pheasants died two months, three months, 15 months and two-and-half years after exposure to infection.

There are many records of the disease in tame pigeons. Plum (1942) recorded an incidence of 6 per cent in 534 examined. Figures provided by other workers vary from 1·3 per cent to 9 per cent. An unusual form of tuberculosis affecting the eyes of pigeons was described by Hepding (1939) and Richter, Van Dorssen and Donkervoet (1953) and Arany (1934) described an infection characterised by arthritis and nodular skin lesions.

Wild Birds

In the writer's opinion the presence of an infectious disease in wild birds is usually suggestive of prior contact with diseased poultry and is not an indication that they are likely to provide a significant or permanent reservoir of infection for domestic fowls. This is certainly so in fowl typhoid and is probably generally the case in tuberculosis. The disease is comparatively rare in free living birds but there are a number of records of its occurrence in several species.

While investigating a possible source of infection in an outbreak of the disease in fowls, Hignett and Mackenzie (1940) found evidence of the disease in three starlings (*Sturnus vulgaris*). Further examinations of starlings in the neighbourhood showed 12 out of 252 (4·8 per cent) to be affected.

In an extensive investigation in Denmark, Plum (1942) examined 999 sparrows and found from 5·3 per cent to 40 per cent of eight flocks infected. These had been in contact with pigs affected with avian tuberculosis; sparrows from many other flocks were largely uninfected. He found that 3·9 per cent of 816 gulls had tuberculosis and also recorded the disease in a kestrel, rook, golden plover, four common scoters (*Oidemia nigra*) and 12 pheasants. A high incidence of the disease in crows in Western Ontaria (25 of 263 examined) was reported by Mitchell and Duthie (1950) but they were unable to determine whether infection resulted from contact with diseased poultry or had spread from crow to crow.

Christiansen, Ottosen and Plum (1946) described a disease in 13 of 230 wood pigeons (*Columba palumbus*), similar to avian tuberculosis except that it was not possible to cultivate the causative organism and McDiarmid (1948) reported ten cases of tuberculosis in 66 wood pigeons shot in Oxfordshire and in 3·85 per cent of 52 unselected wood pigeons. He also found the disease in a rook (*Corvus frugilegus*) and a starling. It is considered that the domestic fowl is an unlikely source of infection for wood pigeons and that more probably the disease spreads from pigeon to pigeon.

Avian tuberculosis has been recorded in a blackbird (*Turdus merula*) (Hare 1932), capercailzie (Grini, 1944; Hulphers and Lilleengen, 1947), sparrowhawk (*Accipiter nisus*) (Harrison, 1948) Australian brown hawk (*Falco berigora*) (Rac, 1951) and in a grey teal duck (*Querquedula gibberifrons*) (Sinkovic, 1954). Jennings (1954) found only one suspicious case, in a wood pigeon, out of 112 wild birds and Keymer (1958) in a survey of *post-mortem* examinations on 513

British birds of 74 different species recorded a single case in an adult pheasant (*Phasianus colchicus*).

In an investigation into the incidence of tuberculosis in wild birds from 1927 to 1930 the writer diagnosed the disease in a lapwing, an oyster catcher (*Haematopus ostralegus occidentalis*), a kestrel (*Falco tinnunculus*) and a pheasant, and in a later survey extending from 1955 to 1959, comprising 1,118 wild birds of 74 varieties avian tuberculosis was found in five herring gulls (*Larus argentatus*), five eiders (*Somateria mollissima*), two pheasants, a golden eagle, a black headed gull (*Larus ridibundus*), a barn owl (*Tyto alba*), a grey lag goose (*Anser anser*) and a cormorant (*Phalacrocorax carbo*).

The case of the golden eagle is of particular interest. It was a hen which was seen to die suddenly, after alighting on its eyrie and was submitted for examination as a suspected case of poisoning. Although it was in good bodily condition there were extensive lesions of tuberculosis and death had resulted from internal haemorrhage following rupture of the diseased liver. In 30 years the writer has seen four cases of advanced tuberculosis in the golden eagle, three in free-flying birds and one in captivity. A possible source of infection in the free-flying golden eagle is a matter for speculation. Its common food is the grouse and the mountain hare in which the writer knows of no record of tuberculosis in Great Britain. A case of what was probably tuberculosis of a black grouse (*Tetrao tetrix*) was described in Norway by Grini (1942) but no evidence of the disease has been seen in any of a very large number of red grouse (*Lagopus scoticus*) from the north of Scotland (Duff, 1960).

Affected pheasants from surrounding woods were considered to be responsible for sensitising cattle to avian tuberculin by Krogh (1937).

Spread of the Disease

Avian tuberculosis is commonly introduced by adult fowls, often stock birds imported for breeding purposes. The faeces of most infected birds contain immense numbers of *M. tuberculosis avium* which contaminate the food and water and the runs and litter. Infection is almost always by ingestion; in some more recent cases, in deep litter, infection by inhalation has been suspected.

A low standard of husbandry generally, with overcrowding and continuous use of land allows a build up of infection. The age at which birds are exposed to an infected environment is of importance; Van Es and Olney (1935) considered that when over two years old there was little chance of them becoming infected.

Poultry runs remain infected for a long time. Schalk, Roderick, Foust and Harshfield (1935) found that the organism survived in the litter and soil of an experimental yard for four years and in a poultry run for at least a year. Careless and improper disposal of carcases may be a means of spread; Schalk *et al.* (1935) found viable organisms 27 months after burial 3 feet deep.

The question of wild birds has already been discussed; although they may sometimes transmit the disease it is very doubtful if they are of much significance.

Schalk *et al.* (1935) found that rats, house mice and field mice were resistant

to avian tuberculosis but that the faeces of rats fed infected material were capable of infecting fowls. On the other hand Plum (1942) examined 846 rats and found an incidence of avian tuberculosis varying from 16.5 to 70 per cent, dependent partly on the age of the rats but more on their contact with tuberculous poultry. It would appear therefore that rats may sometimes be mechanical carriers of the disease but as with wild birds it is probable that generally they are not of great importance.

Egg transmission: A proportion of the eggs laid by some tuberculous hens are infected but it is generally conceded that they are of little if any significance as a means of transmitting the disease. This aspect has been reviewed fully by Feldman (1938) and is summarised briefly here as it is of some interest.

According to Lerche (1931), Schalk (1931) and Fitch and Lubbehusen (1932) less than one per cent of the eggs laid by tuberculous fowls are infected but Klimmer (1931) reported the presence of the organism in as many as 10 per cent. Beller (1931) considered this figure too high and pointed out that while he had never isolated tubercle bacilli from eggs, he had detected acid-fast saprophytes. This is an important observation and casts doubt on estimates based on cultural and staining methods. Later, from a review of the findings of other workers, Klimmer (1932) quoted an infection rate of 5.7 per cent for 1,333 eggs examined. Fedoseev (1956) estimated that seven per cent of eggs laid by tuberculous fowls were infected and Shchepilov (1956) recorded the isolation of the organism from seven of 18 eggs from ducks which reacted to the tuberculin test.

The variations reported in the ratios of infected eggs may be due partly to the use of different techniques for isolating the organism and to differences in positive criteria but they are not altogether surprising. Even greater diversity occurs in other egg transmitted diseases, e.g. the percentage of infected eggs laid by individual carriers of *Salmonella pullorem* or *Salmonella gallinarum* may vary from 0 to 80 per cent (Wilson, 1958).

Egg transmission of the experimentally produced disease was investigated by Stafseth, Biggar, Thompson and Neu (1934). They isolated the organism from 93 eggs (13.96 per cent) laid by 6 of a group of 20 experimentally infected hens but found no evidence that the infected hatching egg could transmit the disease to chicks.

However, it is possible to produce a fatal tuberculosis in chicks within 15 days of hatching by inoculating the yolks of hatching eggs with a culture of avian tubercle bacilli (Fitch and Lubbehusen (1932) and Fedoseev (1956)). The former workers found no evidence of tuberculosis in 697 chicks hatched from eggs of 88 reactors and emphasised that birds in the advanced stages of the disease lay few eggs and a good proportion do not hatch. Harshfield, Roderick and Hawn (1937) examined 1,411 chicks from two flocks of reacting hens, by tuberculin testing and culturally, and also failed to find any evidence that egg transmission is a factor in the spread of the natural disease.

Hulphers (1941) investigated the resistance to boiling of avian tubercle bacilli inoculated into 12 eggs which were treated two at a time for periods of from three to eight minutes. The bacilli in some of the eggs were destroyed

in three, four and five minutes but in others they were viable after six and seven minutes and in one after eight minutes. He considered that the danger to man of tubercle bacilli in eggs should not be underestimated.

Control and Prevention of the Disease

When the disease occurs in a small number of fowls it is a sound policy to dispose of the entire group. Those in good bodily condition may be used for table purposes. Simply remove ailing and thin birds seldom gives satisfactory results as the disease is usually present in an early or sometimes an advanced stage in some of the remaining birds, even although they are apparently in good condition. When a large number of birds is involved, strict culling and moving to fresh ground may be used as an expedient but the aim should be to dispose of the entire group as soon as possible. Although losses from the disease sometimes occur in birds under a year old, the majority are older birds, many of which may be nearing the end of, or have completed a year's production, so that the economic loss from depopulation is usually not excessive. In valuable flocks or where very large numbers of birds are involved a combined programme of culling, tuberculin testing and moving to fresh ground is indicated.

The proper disposal of carcases of infected birds is of importance. They should be removed from the pens as soon as they are seen and incinerated or buried deeply to prevent access by fowls and other farm animals or wild birds, rats and mice.

In view of the tenacity of *M. tuberculosis avium* it is important to rest infected land for as long as possible and during this time it is preferable to use it for cropping rather than for grazing other farm animals.

The main points in prevention are the practice of sound methods of poultry management in all its aspects and to confine the introduction of fresh stock to hatching eggs or day old chicks.

The Tuberculin Test

The information on the intradermal tuberculin test was reviewed by Feldman (1938) and reference has been made to its use in Great Britain by Dalling (1931), Wilson (1931, 1940), Downham (1935), Blount (1938) and Spears and Dobson (1941).

In conjunction with the other measures already described, the test has proved useful in reducing the incidence of avian tuberculosis but its limitations must be appreciated. While a positive or doubtful reaction almost always denotes an infected bird a significant number of diseased birds, in good condition, fail to react. Paludan-Nielson, Plum and Werdelin (1934) found 15 of 30 negative birds to be infected and Spears and Dobson (1941) found 20 out of 43, although 12 of them were in poor condition and would have been eliminated by culling, which under field conditions would normally be carried out before testing.

Wilson (1940) considered the test a means of assessing the incidence of the disease in a flock and of great value in detecting early cases of the disease

thus preventing a build up of infection and pointed out the importance of moving birds which pass the test to clean ground. In one case where this was not done, an incidence of four per cent infection in a pen of pullets rose to 40 per cent a year later. Repetitive testing is usually necessary; this can be costly and if preliminary tests show a high incidence of the disease it is usually best to dispose of the infected stock.

Hinshaw, Niemann & Busic (1932) considered the tuberculin test in turkeys less accurate than in fowls. They found the skin of the wing web to be a better site than the wattle. Davidson (1952) however preferred the latter site and found that some infected birds which gave a positive wattle test showed no reaction in the wing web. In addition to detecting oedema by palpation he found it useful to pass the light of a torch through the wattle.

Craig and Davies (1937) and Gordon *et al.* (1941) found the tuberculin testing of ducks unsatisfactory. Tuberculin testing of geese by intradermal injection under the jaw has been described by Shchepilov (1955).

References

Arany, G. (1934) *Abstract in Vet. Bull.* **5,** 539.
Beller, K. (1931) *Münch. med. Wschr.* **78,** 2168.
Blount, W. P. (1938) *Vet. Rec.* **50,** 1772.
Bunyea, H. (1936) *J. Amer. vet. med. Ass.* **88,** 386.
Cameron, C. A. (1889) *J. comp. Med. and Surg.* **7,** 329.
Christiansen, M., Ottosen, H. E. and Plum, N. (1946) *Skand. Vet Tidskr.* **36,** 352.
Craig, J. F. and Davies, G. O. (1937) *Vet. Rec.* **49,** 29.
Crisp, E. (1869) *Trans. path. Soc. Lond.* **20,** 441.
Crisp, E. (1872) *Ibid.* **23,** 312.
Crisp, E. (1875) *Ibid.* **26,** 249.
Dalling, T. (1931) *Vet. Rec.* **11,** 1202.
Davidson, F. A. (1952) *Personal communication.*
Downham, K. D. (1935) *Vet. Rec.* **15,** 1448.
Duff, R. H. (1960) *Personal communication.*
Edgar, G. (1950) *Aust. vet. J.* **26,** 278.
Fedoseev, V. S. (1956) *Abstract in Vet. Bull.* **27,** 666.
Feldman, W. H. (1938) *Avian Tuberculosis Infection.* London: Baillière, Tindall & Cox.
Feldman, W. H. (1959) *Diseases of Poultry.* Ames: The Iowa State University Press.
Fitch, C. P. and Lubbehusen, R. E. (1932) *J. Amer. vet. med. Ass.* **72,** 636.
Francis, J. (1958) *Tuberculosis in Animals and Man.* London: Cassell.
Gordon, R. F., Garside, J. S., Dobson, N. & Reid, J. (1941) *Vet. Rec.* **53,** 575.
Grini, O. (1942) Cited by Christiansen M., Ottosen, H. E. & Plum, N. (1946) *Skand. Vet. Tidskri.* **36,** 352.
Grini, O., (1944) *Abstract in Vet. Bull.* **14,** 1674.
Hare, T. (1932) *Proc. roy. Soc. Med. Lond.* **25,** 1500.
Harrison, J. M. (1948) *J. Path Bact.* **60,** 583.
Harshfield, G. S., Roderick, L. M., & Hawn, M. C. (1937) *J. Amer. vet. med. Ass.* **91,** 323.
Hebb, R. G. (1888) *Trans. path. Soc. Lond.* **39,** 471.
Hepding, L. (1939) *Abstract in Vet. Bull.* **11,** 742.
Hignett, S. L., and Mackenzie, D. A. (1940) *Vet. Rec.* **52,** 585.
Hinshaw, W. R., Niemann, K. W. & Busic, W. H. (1932) *J. Amer. vet. med. Ass.* **80,** 765.
Hjarre, A. & Wramby, G. (1945) *Skand. Vet Tidskr.* **35,** 449.
Hulphers, G. (1941) *Abstract in Vet. Bull.* **11,** 831.
Hulphers, G. & Lilleengen, K. (1947) *Abstract in Vet. Bull.* **20,** 844.
Jennings, A. R. (1954) *J. comp. Path.* **64,** 356.
Johnson, H. W. and Ranney, A. F. (1956) *Year Book of Agriculture,* Washington: U.S.D.A.
Keymer, I. F. (1958) *Vet. Rec.* **70,** 713.
Klimmer, M. (1931) *Münch. med. Wschr.* **78,** 1212.

KLIMMER, M. (1932) *Abstract in Vet. Bull.* **3,** 663.
KOCH, R. (1902) *Trans. Brit. Cong. Tuberculosis.* **1,** 23.
KROGH, P. R. (1937) *Abstract in Vet. Bull.* **9,** 675.
LERCHE, (1931) *Abstract in Vet. Bull.* **1,** 145.
AGRICULTURE RESEARCH SERVICE. *Losses in Agriculture.* Washington: U.S.D.A.
MCDIARMID, A. (1948) *J. comp. Path.* **58,** 128.
MAGNUSSON, H. (1945) *Abstract in Vet. Bull.,* **17,** 843.
MATHESON, D. C. and WILSON, J. E. (1933) *Proc. 5th World's Poult. Congr.* **1,** 3.
MITCHELL, C. A. and DUTHIE, R. C. (1950) *Canad. J. comp. Med.* **14,** 109.
MORGAN, D. O. and WILSON, J. E. (1938) *J. Helminth.* **16,** 165.
PALUDAN-NIELSEN, O., PLUM, N. and WERDELIN, C. (1934) *Abstract in Vet. Bull.* **5,** 569.
PLUM, N. (1942) *Abstract in Vet. Bull.* **13,** 2802.
RAC, R. (1951) *Aust. vet. J.* **27,** 209.
RICHTER, J., VAN DORSSEN, C. A. & DONKERVOET, J. (1953) *Abstract in Vet. Bull.* **23,** 3263.
ROBIN, A. H. (1950) *Aust. vet. J.* **26,** 274.
SCHALK, A. F. (1931) *J. Amer. vet. med. Ass.* **78,** 437.
SCHALK, A. F., RODERICK, L. M., FOUST, H. L., & HARSHFIELD, G. S. (1935) *Tech. Bull. N. Dak. agric. Exp. Sta.* **279,** 46.
SHCHEPILOV, N. S. (1955) *Abstract in Vet. Bull.,* **26,** 1112.
SHHECPILOV, N. S. (1956) *Ibid.* **26,** 3357.
SIBLEY, W. K. (1890) *J. comp. Med. and vet. Arch.* **11,** 317.
SINKOVIC, B. (1954) *Aust. vet. J.* **30,** 215.
SLAVIN, D. (1937) *Unpublished work.*
SPEARS, H. N., & DOBSON, N. (1941) *Vet. Rec.* **53,** 365.
STAFSETH, H. J., BIGGAR, R. J., THOMPSON, W. W. and NEU, LISA (1934) *J. Amer. vet. med. Ass.* **85,** 342.
SUTTON, J. B. & GIBBS, H. (1884) *Trans. path. Soc. Lond.* **35,** 477.
TERESHCHENKO, I. K. (1957) *Abstract in Vet. Bull.* **28,** 1318.
VAN ES, L. & OLNEY, J. F. (1935) *J. Amer. vet. med. Ass.* **86,** 390.
WHITE, E. G., & ELLIS, A. A. B. (1939) *Vet. Rec.* **51,** 475.
WILSON, J. E. (1931) *Vet. Rec.* **11,** 406.
WILSON, J. E. (1940) *J. roy. sanit. Inst.* **60,** 338.
WILSON, J. E. (1945) *Unpublished work.*
WILSON, J. E. (1958) *Unpublished work.*
ZARGAR, S. L. (1946) *Indian J. vet. Sci.* **16,** 26.

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RECENT CHANGES IN TUBERCULOSIS INCIDENCE AND MORTALITY IN SCOTLAND

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Substantial changes have occurred in the incidence of new cases of tuberculosis and the frequency of death from this cause during the present century in response to a progressive improvement in the standard of living and to the development of more effective techniques of prevention, case-finding and treatment, as well as to the adverse effects of two world wars. Even before the introduction of the specific measures which have formed the basic component of the control programme during the past decade tuberculosis mortality and morbidity were gradually falling, a trend usually attributed to increased resistance resulting from improved social conditions, to increasing facilities for the segregation of infectious persons and to the progressive control of the spread of disease of bovine origin. This paper sets out to present broadly the changes which have occurred in Scotland, measured by the changing frequency of death, the incidence of new cases and the prevalence of infection.

Although mortality data are available from the records of the Registrar General from the middle of last century, it was not until 1914 that all forms of tuberculosis were by statute made notifiable to Medical Officers of Health. It is convenient, therefore, to consider these trends from the beginning of the first World War. Another index of prevalence has recently been obtained from the results of tuberculin tests carried out among school children in association with the arrangements for B.C.G. vaccination introduced in selected areas of Scotland in 1952.

TUBERCULOSIS MORTALITY

Changes in Mortality between 1914 *and* 1959

During the first World War about 7,500 persons (155 per 100,000 of the population) died each year from tuberculosis. The average annual figure for the period 1950-9 was rather less than 1,200 (20 per 100,000) representing a reduction of 84 per cent. In the earlier period about two-thirds of the deaths were attributed to respiratory disease compared with four-fifths in the latter. Expressed in another way, deaths from respiratory disease fell to about 20 per cent and from all other forms of tuberculosis to about six per cent of their 1914-19 value. These changes are illustrated in Table I and Fig. 1. It will be seen that the progressive mortality reduction during the inter-war period was

reversed for respiratory disease and substantially slowed down for other forms of tuberculosis during 1940-49. Since then the downward trend has been resumed at a more rapid rate than at any time in the past. This is illustrated by the fact that the average annual reduction in the death rate for

TABLE I—TUBERCULOSIS DEATHS AND CHANGES IN THE RATES IN SCOTLAND DURING 1914-59

	Respiratory tuberculosis		*Other forms of tuberculosis*	
	Mean annual deaths	*Percentage change in death rate*	*Mean annual deaths*	*Percentage change in death rate*
1914-9	4,986	—	2,487	—
1920-9	3,730	−26	1,752	−31
1930-9	2,840	−24	976	−44
1940-9	3,120	+10	813	−15
1950-9	1,029	−79	151	−82

respiratory diseases between 1914 and 1939 was less than three per cent compared with an average fall of eight per cent each year between 1950 and 1959. The more rapid improvement in these rates during the last ten years is attributable to the introduction of drug therapy and to the fact that more efficient-case finding by the diagnostic and mass radiography services have brought patients under treatment at a much earlier stage of the disease. As will be discussed later, the outlook for the tuberculosis patient is now substantially better than at any time in the past.

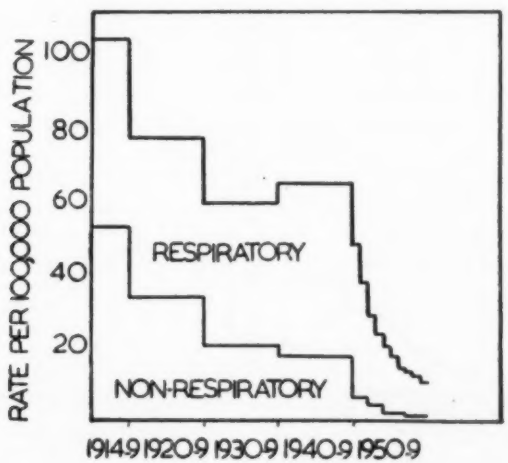

FIG. 1. Tuberculosis death rates in Scotland 1914–59; rates per 100,000 population.

Mortality Changes in the Two Sexes at Different Ages

The crude rates of mortality already described have been accompanied by substantial alterations in the experience of persons of different age and sex in recent years. These changes are illustrated by the trends of mortality from respiratory disease and the observations which follow are limited to this form of tuberculosis. The death rate for males has always exceeded that for females due mainly to an excess of mortality in older persons. The peak for men has gradually moved from the young adult, at the beginning of the century, to the older age range, an experience which has not been shared by women until the last few years. The rates of mortality at different ages in the two sexes are contrasted for the years 1900, 1930 and 1958 in Fig. 2. The changes in these rates between 1930 and 1958 are shown in Table II.

TABLE II—RESPIRATORY TUBERCULOSIS DEATH RATES IN 1958 EXPRESSED AS A PERCENTAGE OF THE RATES IN 1930

Age groups (years)	−14	15–24	25–34	35–44	45–54	55–65	65+	*All ages*
Males	2·5	1·4	9·7	13·5	23·7	57·4	116·7	25·4
Females	2·9	2·0	15·1	24·3	12·5	14·3	63·0	13·8

The improvement in mortality has been substantial in both sexes but much greater among females. The rates for younger males have fallen more and for men in the older age groups considerably less than their female counterparts.

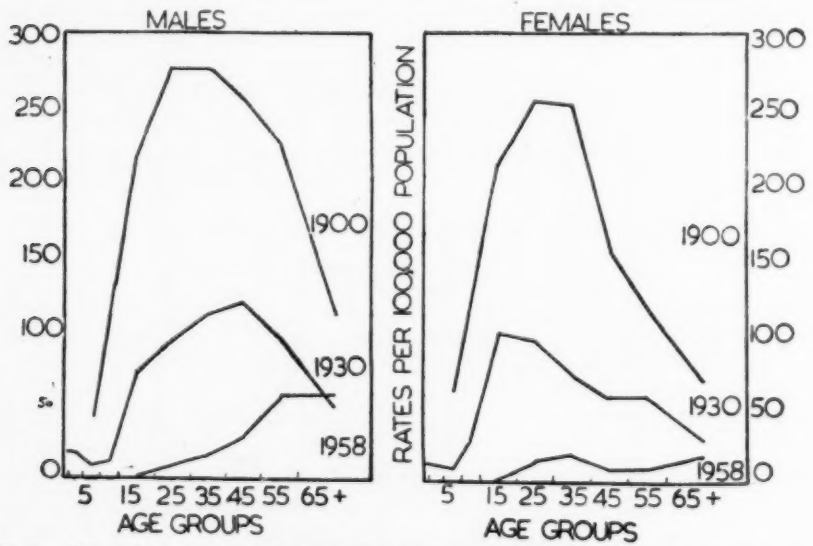

FIG. 2. Age and sex specific death rates for respiratory tuberculosis in Scotland 1900, 1930 and 1958.

Progressively less improvement has occurred in men with advancing years, the 1958 rate exceeding the 1930 value by 17 per cent over the age of 65. A significant observation is that only four children under the age of 15 years died from respiratory tuberculosis in 1958 compared with 169 in 1930. This changing emphasis can be expressed in another way—deaths over 45 years contributed 81 per cent of all deaths from respiratory tuberculosis among men and 43 per cent among women in 1958 compared with 36 per cent and 23 per cent respectively in 1930.

Tuberculosis Deaths compared with Deaths from All Causes

Another method of expressing the improvement in the tuberculosis position which has occurred in recent years is to contrast the proportion of all deaths attributed to this cause at different periods. These data, reproduced in Table III, show that the disease has substantially fallen in prominence as a cause of mortality although, at about one per cent of all deaths, it is still an important cause, especially in view of the high efficiency of modern treatment.

TABLE III—TUBERCULOSIS DEATHS EXPRESSED AS A PERCENTAGE OF DEATHS FROM ALL CAUSES IN SCOTLAND, 1900–1959

	Respiratory		*Other forms*	
	Males	*Females*	*Males*	*Females*
1900	9·0	8·8	3·9	3·5
1930	4·8	4·6	1·9	2·0
1958	1·4	0·7	0·09	0·07

TUBERCULOSIS MORBIDITY

Changes in Morbidity between 1914 *and* 1959

During the first World War an average of 8,500 persons (177 per 100,000 of the population) were notified to Medical Officers of Health annually as suffering from respiratory tuberculosis compared with a figure of 6,700 (131 per 100,000) during 1950-9. This represents a reduction of 26 per cent. Rates for non-respiratory disease during the earlier period are not available in an appropriate form but the reduction in the incidence of such cases is estimated to be in excess of 80 per cent. These changes are illustrated in Fig. 3 and Table IV. As in the case of deaths the number of new cases notified each year was gradually falling in the period between the wars. This was followed by a substantial increase in the incidence of respiratory disease during 1940-9 and by a resumption of the downward trend in 1950-9 at a more rapid rate than at any previous time. During the latter period the average annual rate of fall has been over five per cent compared with about one per cent in the inter-war years. The most rapid rate of reduction has followed the two year mass radiography campaign which was carried out in Scotland during 1957 and 1958 resulting in the examination of nearly two million persons and the identification of over 4,000 cases of active tuberculosis. Between 1950 and 1955 the number of new notifications of respiratory disease fell by 20 per cent

from 8,135 to 6,541 and between 1955 and 1959 by 43 per cent to 3,733, the lowest figure on record. This rate of fall has, for the first time since the pre-war years, been comparable with the reduction in the death rate.

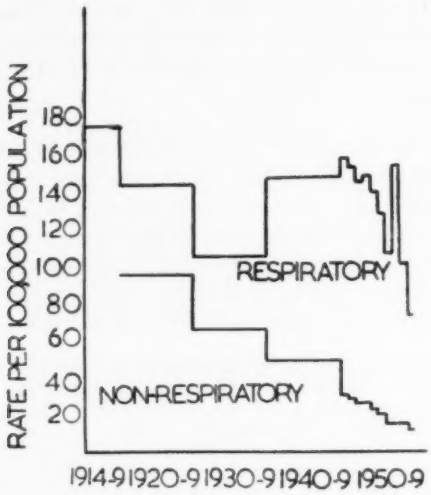

FIG. 3. Tuberculosis notifications in Scotland 1914–59; rates per 100,000 population.

TABLE IV—TUBERCULOSIS NOTIFICATIONS AND CHANGES IN THE RATES IN SCOTLAND DURING 1914–59

	Respiratory tuberculosis		*Other forms of tuberculosis*	
	Mean annual notifications	*Percentage change in notification rates*	*Mean annual notifications*	*Percentage change in notification rates*
1914–9	8,542	—	—	—
1920–9	7,005	−19	4,661	—
1930–9	5,104	−27	3,247	−31
1940–9	7,146	+40	2,346	−26
1950–9	6,716	−10	1,046	−59

Morbidity Changes in the Two Sexes at Different Ages

When the age and sex experience of notifications in 1959 is compared with that in 1930 some major changes in the distribution of morbidity can be demonstrated. The rates for males, which have been consistently and substantially in excess of those for females, show, as was observed in the trends of mortality, a definite shift of the highest levels from the younger to the older adult age period. No similar tendency has been observed for females. These rates are illustrated in Fig. 4 and the changes in them in Table V. It will be seen that the frequency with which new cases are now being reported is

substantially less for both sexes in all but the older age groups and that the rate of reduction has been substantially greater among females. An outstanding feature has been the increase in morbidity among men of 45 years of age and over, an observation in keeping with the mortality experience.

TABLE V—RESPIRATORY TUBERCULOSIS NOTIFICATION RATES IN 1959 EXPRESSED AS A PERCENTAGE OF THE RATES IN 1930

Age groups (years)	−14	15–24	25–34	35–44	45–54	65+	*All ages*
Males	43·1	57·6	56·7	47·9	101·5	183·0	69·5
Females	48·5	58·9	54·8	58·9	61·9	93·1	53·8

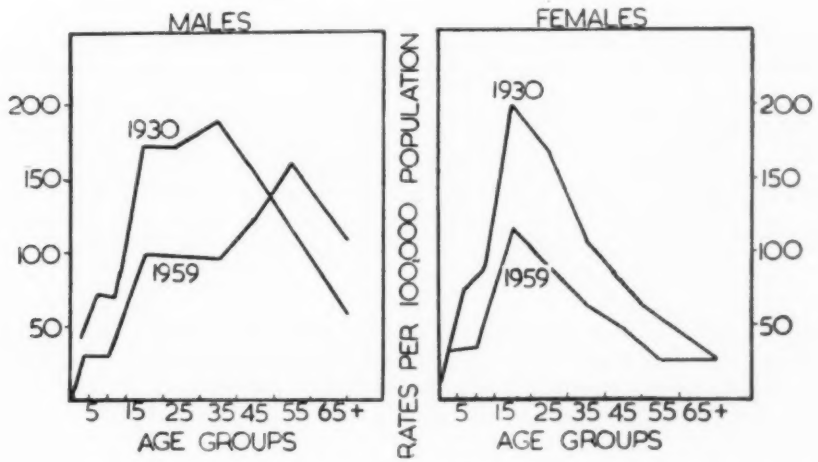

FIG. 4. Age and sex specific notification rates for respiratory tuberculosis in Scotland, 1930 and 1959.

CHANGES IN THE MORBIDITY/MORTALITY EXPERIENCE

The morbidity/mortality ratio, that is the number of new notifications received for each death reported over a given period, is a convenient way of expressing the changing outlook for tuberculous patients at different times. The ratios for 1914-59 are reproduced in Table VI. This shows that, until 1939, less than two new cases were reported for each death from respiratory tuberculosis and about three for every death from other forms of the disease. During 1950-9 these figures rose to 6.5 and 6.9 respectively indicating a substantial

reduction in the case of fatality rate. In addition there is a considerably better outlook for the patient whose disease is identified early in life. This observation is illustrated in Table VII which presents the morbidity/mortality ratios at different ages in the two sexes for respiratory tuberculosis in 1959 compared with experience in 1930. There is no doubt that this change in prognosis has

TABLE VI—NUMBER OF NEW NOTIFICATIONS RECEIVED FOR EACH DEATH REPORTED

	Respiratory tuberculosis	*Other forms of tuberculosis*
1914–9	1·71	—
1920–9	1·88	2·66
1930–9	1·80	3·33
1940–9	2·30	2·89
1950–9	6·53	6·93

TABLE VII—NUMBER OF NEW NOTIFICATIONS RECEIVED FOR EACH DEATH REPORTED IN SCOTLAND AT DIFFERENT AGES IN THE TWO SEXES DURING 1930 AND 1959 RESPIRATORY TUBERCULOSIS

Age groups (years)		−14	15–44	45+	*All ages*
1930	Males	5·7	2·0	1·3	1·9
	Females	4·6	1·8	1·1	1·8
1959	Males	95·0	11·9	3·0	5·1
	Females	109·0	8·3	3·9	7·4

resulted from the more efficient case-finding programme which is bringing patients under medical care at a much earlier stage of their disease and from the highly effective treatment which is now being employed.

INFECTION RATE

In 1949 the Department of Health for Scotland introduced a voluntary scheme of tuberculin testing and B.C.G. vaccination for persons exposed to special risk of contracting tuberculosis. In 1952 this programme was extended to include children approaching school leaving age in a few areas and later in the whole country. Until the development of this scheme little or no useful information was available for the measurement of the frequency and infection or the changes that were taking place. Since 1952 about 400,000 children have been tested by the Mantoux or the Heaf technique. The results of these tests, reproduced in Table VIII, show that the amount of infection in the community, measured in this way has been falling progressively over the last few years. The higher rate of increase in the proportion of negative reactors between 1952 and 1955 is due in some measure to the fact that the earlier

schemes of testing were carried out in those areas where the prevalence of tuberculosis was known to be highest.

TABLE VIII—RESULTS OF TUBERCULIN TESTS OF SCHOOL LEAVERS IN SCOTLAND, 1952–9

		1952	1953	1954	1955	1956	1957	1958	1959
Number tested		8,843	31,447	59,352	48,319	58,803	57,577	42,546	58,316
Negative reactors	Number	3,860	16,378	37,626	32,857	42,144	41,888	31,643	46,466
	per cent	44	52	63	68	72	73	74	80

DISCUSSION

Tuberculosis has long been regarded as a major cause of ill health and death during the most productive years of life. Until a few years ago it was singled out as the most important health problem in Scotland and special steps were taken by the Government to intensify the control programme by the inclusion of new and more refined measures of prevention, case-finding and treatment. Most important among these were the schemes of B.C.G. vaccination, the extension of diagnostic radiology and photofluorographic services and the progressive improvement of clinical departments in hospitals and out-patient clinics. Probably the most valuable contribution to progress has been the discovery and use of drugs of specific value to the cure of the disease, the effect of these having been to improve substantially the expectation of successful treatment, to reduce the duration of incapacity, to minimise the prospects of subsequent relapse and to prevent the future spread of infection. There is no doubt that the better diagnostic facilities of the last few years have been used to good effect and that a substantially higher proportion of new cases are being brought under treatment at an earlier and more treatable stage than ever before. To some extent the rather slower reduction of morbidity, compared with mortality experience, during recent years can be attributed to the fact that the case-finding programme is now uncovering a much higher proportion of the tuberculosis reservoir and that disease of certain grades of severity, which would not have been included in the data in the past, are now being reported. It is more than likely, therefore, that the degree of control of the disease is increasing more rapidly than the morbidity data would suggest. There is still much to be done, particularly among population groups which suffer from higher than average prevalence. While it is not the purpose of this paper to enlarge on this aspect of future control it is appropriate to mention the importance now attached to improving the search for new cases among older men.

SUMMARY

This paper illustrates the substantial changes, almost all in the direction of improvement, which have now occurred in the incidence of death from tuberculosis in the last few years. There are indications that the disease is now responding to control measures more rapidly than at any time in the past, the only group of the population in which retrograde trends have occurred being men in the older age groups.

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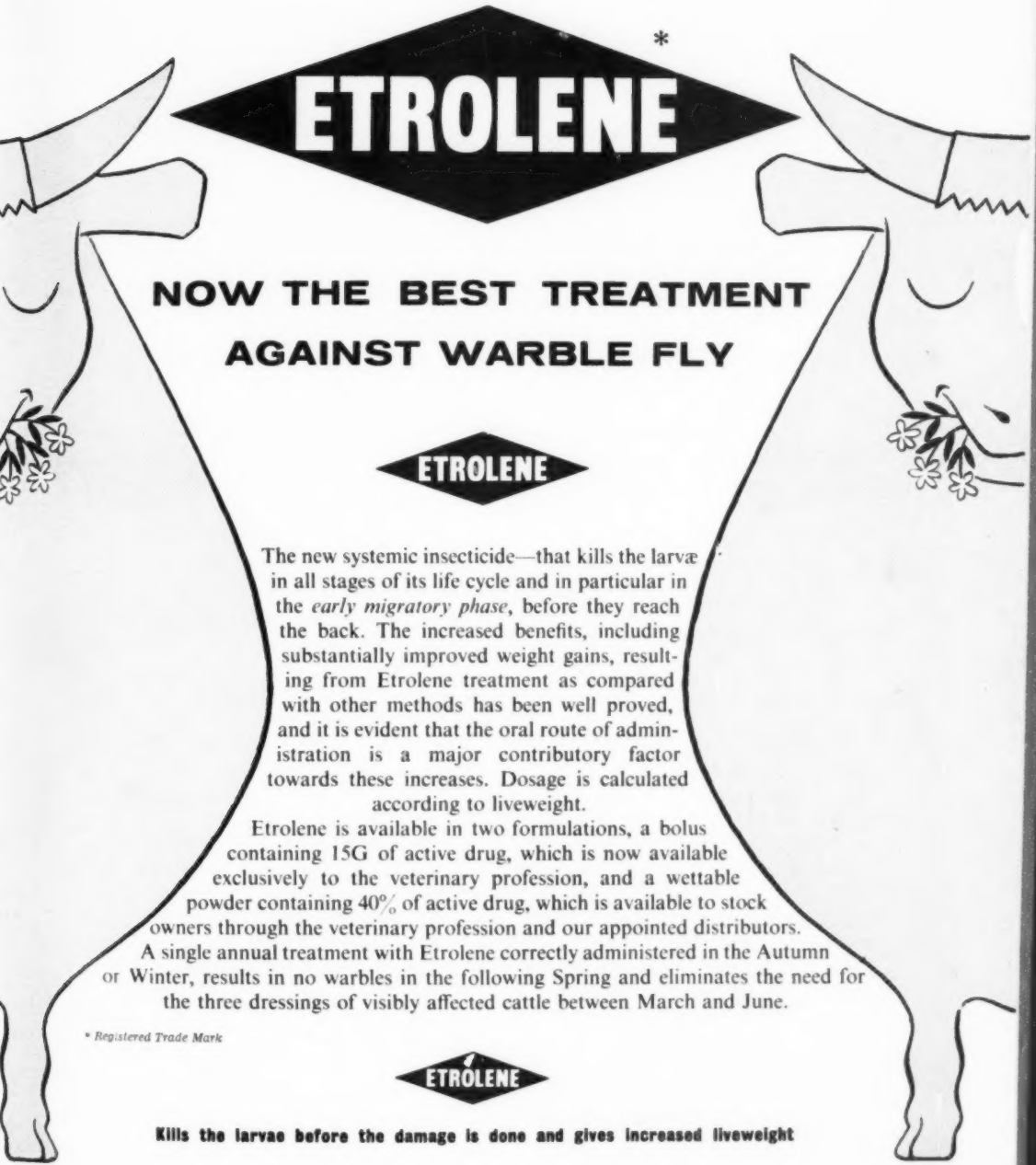
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REFERENCES

Worden A. N. 1958 a. "The feeding of fresh and stored chick mashes containing cod liver oil". Journal of Agricultural Science, Volume 50, number 3, pages 340 and 343.

Worden A. N. 1958 b. "The feeding of cod liver oil to growing/fattening pigs". Journal of Agricultural Science. Volume 50, number 3, pages 344-345.

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REVIEW

Report on the Animal Health Services in Great Britain 1958. MINISTRY OF AGRICULTURE, FISHERIES AND FOOD AND THE DEPARTEMNT OF AGRICULTURE FOR SCOTLAND. London: Her Majesty's Stationery Office. 6s.

This report, which follows the same pattern as those in previous years, refers to the activities of the Animal Health Division, the Veterinary Laboratories and the Veterinary Investigation Centres of the Ministry of Agriculture, Fisheries and Food during 1958. There is also an account of the work carried out at the two cattle breeding centres with which the Ministry's Animal Health Division is associated, namely Reading and Ruthin.

From the point of view of notifiable disease outbreaks 1958 was a comparatively good year. There were 116 outbreaks of foot and mouth disease, a decrease compared with 1957. Nearly two-thirds of the primary outbreaks were thought to be from the Continent and it is anticipated that with the improvement of the foot and mouth disease position on the Continent there should be progressively less infection from this source. We now know from the record of outbreaks for 1959 that this optimism was justified. For the second year in succession there was a decrease in the number of cases of anthrax and the low level of 167 cases was the lowest for 10 years. It would be interesting to know if the greatly reduced incidence of anthrax in 1957 and 1958 could be correlated with a change in the sources of certain animal feeding stuffs during these years. There was also a decrease in the incidence of fowl pest at 759 outbreaks, but this report covers a period before the steep rise in the incidence of this disease in 1959. A rise is recorded in the incidence of swine fever but it is of note that only four of the 1,263 outbreaks occurred in Scotland.

It was another year of steady progress towards the eradication of bovine tuberculosis and by its end only 15 per cent of the cattle in Great Britain were not in attested herds or attested areas and the report anticipates virtual eradication over the whole country by autumn 1960.

It is interesting to note from the report that contagious abortion vaccinations under the calfhood vaccination scheme remained at the same level as in previous years but that there was an increase of 5 per cent in the total issues of Strain 19 vaccine.

The report contains the usual information on the control of import and export of animals and their products and special attention is drawn to the decision of the Australian Government to ban the importation of all ruminants and swine on account of the risk of introducing blue tongue disease.

A large proportion of the report is devoted to the work carried out at the veterinary laboratories of the Ministry. This includes a summary of the research projects in connection with bacterial, virus, and parasitic diseases and also metabolic and nutritional conditions in the farm species. In this section an account is given of a very great deal of work of the utmost importance to the veterinary profession and the agricultural community and it is quite impossible to review each project adequately in a few sentences. One might, however, arbitrarily select for mention four projects to indicate the nature and importance

of this work, namely, the effects of vaccination with Strain 19 on the various tests used for the diagnosis of brucellosis, the Johne's disease vaccine field trials, the results of the examination of samples from clinical cases of mastitis and the trials with DOW E.T. 57 in the control of ox warble infestation. The results of the brucella vaccine work emphasises the importance of confining this vaccination to young animals if an eradication scheme is to be adopted. The long term Johne's disease vaccine trials are still encouraging after 11 years, although by 1957 the general rate of losses in both vaccinated and unvaccinated herds had become so low as to make the number of losses compared in the respective groups very small. It is also gratifying to see recorded the initiation of a second Johne's disease vaccination field trial on a larger scale. The examination of mastitis samples again emphasises the small proportion of samples going to Weybridge which are affected with *Streptococcus agalactiae*, the predominance of staphylococci and the wide variety of organisms involved. The encouraging trials with DOW E.T. 57 would appear to be an important step in the development of alternative methods of controlling the ox warble fly.

A very brief account is given of "some of the more important investigations" of the veterinary investigation service. It is stated that the most striking feature during 1958 was the high incidence of parasitism. Perhaps a more detailed account of the work of this service would be both interesting and beneficial.

The account of the work at the Reading Cattle Breeding Centre makes fascinating reading. A specially interesting observation was that in studying herd infertility problems over two years it was found in each year that the herbage calcium oxide levels on "infertile farms" were higher than those on "fertile farms"; however, the number of farms involved was small and a particularly wide variation in calcium oxide levels was encountered on the "infertile farms" in the second year. Another finding at this centre was that frozen bovine semen held at temperatures below—70°C. for periods up to four years showed no loss in fertility.

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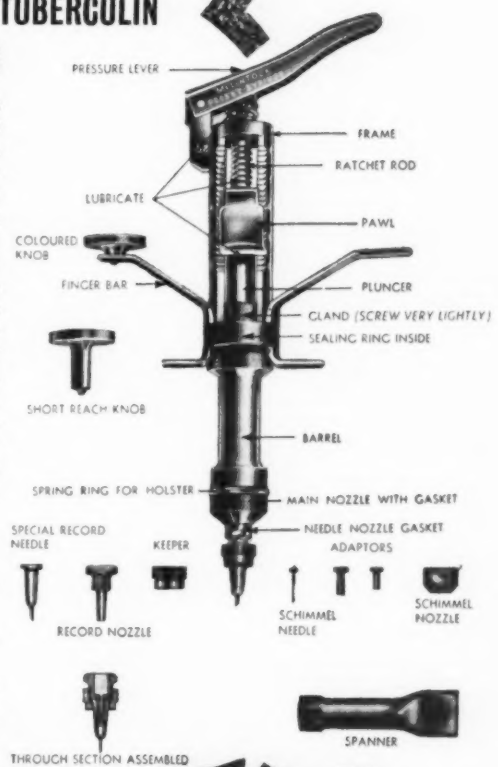

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